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Articles

Reviews

Scandinavian Literature

Conferences

Annotations

RANGE MANAGEMENT RESEARCH METHODS IN THE WESTERN UNITED STATES

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THE great range land in the western half of the United States of America covers a territory approximately 1,000 miles wide and 1,200 miles long, within which some 728 million acres of mountains, foothills, plains, and semi-desert are grazed at various seasons of the year by millions of cattle, horses, sheep, and goats, as well as big game and other wild animals.

The range research problem is to determine how the continued productivity and use of this vast native forage resource can be maintained at the highest level in harmony with economic livestock production and the conservation of other resources on the range, such as timber, and water for irrigation ; and with the feed production of the associated lands in cultivation. This means working out the proper utilization and management of the rather sparse vegetation growing under usually low rainfall and easily damaged by too heavy grazing, especially during recurrent severe drought periods.

In planning a comprehensive research attack, allowance must be made for the distinct differences of vegetation, topography, climate, and the character of grazing and agricultural use in different portions of the huge range area. Accordingly, within this western domain the Forest Service has organized six regional forest and range experiment stations, each fully equipped and staffed and in charge of a director who co-ordinates the research on forest and range lands, involving timber management, range management, watershed management, and related studies. Within each region have been developed several experimental forests or ranges, representative of major types of vegetation, or of use conditions, on which range research is being conducted under four main phases : range management, artificial revegetation, range forage investigations, and range watershed protection. The organization and scope of the research under each of these phases have been outlined in detail in *Herbage Reviews* (**3**) by W. R. Chapline, Chief of the Division of Range Research, and recently in *Bull.* 26 of the Herbage Publication Series (**22**).

The range management phase of Forest Service research is covered in this paper, which indicates some of the more important experimental methods employed. These methods will be illustrated with problems of outstanding importance, since it is the

problem and the available facilities that determine the experimental methodology. Space does not permit detailed description of specific methods as applied on each of the twenty experimental range areas in the western United States, nor is this necessary to a general understanding of the main approach to problems. A rather full discussion of the research approach at the Jornada Experimental Range in southern New Mexico will illustrate application of many methods now in use. This range is representative of semi-desert grasslands of southern Arizona, New Mexico and wes-

tern Texas, and has been under experimental management for 25 years. Briefer consideration of the approach to several other problems of major importance on different experimental ranges will illustrate certain necessary modifications and differences in methodology.

1. Comprehensive Management Studies on Semi-Desert Ranges

The fortunes of the range livestock business on semi-desert ranges fluctuate considerably, being governed mainly by climatic vicissitudes. Prosperity accompanies years with higher rainfall and good forage production, while adversity comes in dry years with limited forage growth and scanty water supplies. The vegetation is naturally sparse, usually covering only 0.1 to 0.3 of the ground, with a delicate balance frequently disrupted by severe drought. The average annual rainfall on the Jornada Experimental Range is only 9 inches, more than half of which comes during the months of July, August and September. The tuft-forming perennial grass forage, which makes up 80 per cent of the vegetation, is grown during this summer period, and is the principal basis of the yearlong grazing by cattle. Only in occasional years of unusually favourable rainfall is there appreciable forage growth during the spring. Forage production is so uncertain that large areas, thousands of acres in size, are necessary for a practical ranch unit. Since this yearlong range is better suited to grazing by cattle-breeding herds than to fattening young animals, the livestock industry in this section is mainly one of calf production.

The problem is how to produce cattle economically on this semi-desert yearlong range with its wide fluctuations in forage production. The Jornada Experimental Range is an area of 185,000 acres, forming a single cattle ranch suitable for experimental purposes, adaptable as a demonstration area, and easily administered. With such a large area, the experimental approach is a combination of empirical experiments in large pastures, practical tests of cattle management on the range, and detailed studies of the important forage plants and range types. The entire range is fenced into several large pastures, separating the main forage types and providing four main seasons of grazing, which research to date indicates furnish best practical management or justify further tests :

1. Summer grazing in pastures supporting predominantly tobosa grass (*Hilaria mutica*) and its associated species.

2. Yearlong grazing in a pasture in which all the vegetative types on the experimental range, both perennial grass and shrub types, are represented and stocking is rather uniform throughout the year.

3. Semi-deferred grazing in a pasture containing mainly black grama (*Bouteloua eriopoda*) and mesquite (*Prosopis glandulosa*)—sand dune types, grazed very lightly in summer and sufficiently heavily during the rest of the year to utilize the year's forage.

4. Deferred grazing in a pasture of black grama grass, with utilization deferred mainly until winter and spring.

The entire experimental range is stocked in conformity with the general aim of providing sufficient range forage to support the cattle in all except the most severe

drought years, although practical considerations occasionally interfere with the literal execution of the plan for season and degree of use in each pasture. A breeding herd of some 1,200 Herefords is grazed on the range, with seasonal movements of animals between pastures as indicated above.

Studies Aimed at Maintaining Forage Production

Studies to determine potential forage production and methods of attaining such production are conducted simultaneously. Both involve: (1) general relation of grazing and climate to range maintenance; (2) determination of relative forage values of various plants on the range; (3) life histories of the more important or abundant species to determine how and when they grow and reproduce; and (4) plant succession and change from year to year as to both species and forage production. It is particularly important to determine the factors responsible for plant change, such as climate, soil, grazing, and plant competition. These features may be arranged along ecological lines of research, aimed at the threefold problem of maintaining forage production on the better grass types, of increasing production on the poorer shrub types, and of holding up production in good years and bad.

The combination of the seasonal grazing between the pastures, and the location of permanent study plots within the pastures has made it possible to evaluate the effect of season and intensity of grazing upon forage growth and maintenance. Results are observed both in extensive surveys and in more detailed measurements on plots. For the most part, grazed quadrats are located at 0.5 mile and 1 mile intervals along lines radiating from permanent watering places, as grazing is heaviest near these watering places, and gradually diminishes at greater distances. A few plots contain certain types of vegetation without relation to degree of grazing. In the perennial grass types, the quadrats are 1 meter square, but plots 10 meters square are used to follow changes of the large shrubs in the mesquite (*Prosopis glandulosa*) sand dunes.

The quadrats are charted each fall near the end of the normal growing season, since it was early determined that fall charting best furnished comparable data from year to year. The boundary of each perennial grass tuft at 1 inch above the soil surface is mapped on a quadrat sheet, and the area computed in square centimeters. Other perennial herbaceous plants are located on the sheet and the number totalled by species. The annual plants are merely counted and recorded on the quadrat sheet by decimeter strips. Full notes are made of all conditions influencing each quadrat and of such features as height growth, flower stalk production, and related matters for the more important plants.

The greatest importance is attached to accuracy and completeness of records and detailed instructions for handling quadrats have been worked out by McGinnies (**10**). Mapping of the plots is greatly facilitated by the chartograph. This instrument, developed by Hill (**7**), consists of a low table and a set of pantograph arms which permit the plant clumps to be traced on a quadrat sheet reduced to one-fifth. Substantial mechanical improvements have been made in the chartograph by Pearse et al. (**12**).

The chart quadrat method was decided upon for detailed records of vegetation on the Jornada Range for several reasons : (1) it reflects the change in black grama (*Bouteloua eriopoda*), the most important perennial grass, from year to year, both as to size and shape of individual tufts, in such a way as to trace effects of weather and grazing and to reveal the character and amount of reproduction ; (2) it furnishes similar information for numerous other plant species, varying in growth form and habit, including broad-leaved herbs and small shrubs, many of which are aggressive, low value plants ; (3) it measures the vegetation and its changes under several degrees of grazing ; (4) it indicates the competition between plants on the same area, and furnishes accurate data as to the outcome of such competition ; (5) through combined tuft areas and height measurements it gives some measure of forage volume production by species from year to year ; and (6) it furnishes the data in definite quantitative form so that plant change can be correlated with concurrent measurements of climatic and physiographic factors.

Adequate sampling with quadrats of the entire vegetation in each of the large pastures on the Jornada Range has not been attempted. However, sufficient quadrats are recorded to furnish a reasonably sound check of the main vegetative and grazing conditions and management features.

Determining Relative Forage Values

Relative forage values of plants on the Jornada Range were first estimated from ocular observations of the degree to which the species were utilized when the various parts and types of range were suitably grazed. Such percentages, based upon the current year's growth, represent the proper use factors employed for individual species in range surveys, as described more fully by Pickford (**15**), although they were formerly defined as the palatability or palatable forage of each plant. The preliminary figures for species on the Jornada Range were improved and refined over the years from data obtained in a number of ways :

1. Supplemental notes on quadrats, which record separately the vegetation on the quadrat itself, and for the adjoining area, the estimated proportion of each species in the stand and the degree to which it has been grazed. Utilization observations are made both in fall when the quadrats are charted and again in June. The records of use are checked against the ability of plants to maintain their productivity over the years.

2. Utilization inspections of the pastures are made in October, December and June each year, when estimates are made of the percentage of herbage that has been grazed on each species within each type of vegetation and each recognizable class of grazing intensity.

3. Special studies, including (a) actual observations of cattle grazing, through field glasses if necessary, to note species and amount eaten, and (b) permanent plots, 1 rod square, on grazed range, observed at 2 weeks' or monthly intervals to measure or estimate and record the percentage of herbage grazed on each species, especially to establish livestock preferences at different seasons of the year.

Analysis of these data show directly the dominant plants that furnish the feed on the range, but the establishment of proper use factors rests upon careful determination of proper utilization of the range through all of the methods here indicated. This includes study of the resistance of the important forage species to grazing, to provide for their maintenance and reproduction. Clipping provides a direct attack and close control in studying the effect of different frequencies and intensities of harvesting upon forage production and plant density. Although it is impossible to reproduce the actual effects of range grazing by artificial harvesting, the results of clipping *Bouteloua eriopoda* and *Hilaria mutica* on the Jornada (**2**) have been of value in supplementing grazing studies.

Plant Life Histories

Much of the information on life histories is obtained from phenological records on selected plots. Stem height and leaf length are measured on permanently marked specimens of the important forage plants at weekly or 10-day intervals during the growing season, and stages of development, such as flowering, seed maturity, and seed dissemination, are clearly indicated.

Ocular examinations indicate which species reproduce vegetatively by means of stolons or rhizomes, both frequent methods of propagation among grasses in the Southwest. Detailed records on the chart quadrats show how and when such vegetative reproduction takes place, and how it is affected in the various species by weather and grazing. The quadrat records also show tillering of grasses, and the extent to which individual tufts solidify and spread, or break up over the years (**11**).

Special studies are made of reproduction by seed. Plant growth records indicate the formation, maturity, and dissemination of seed, but in addition, seed collections are made of the important grasses, weeds, and shrubs each year. Florets of grasses with small seed are carefully examined with a hand lens to establish the approximate proportion of seed actually matured. Germination tests are then made to determine seed viability, both in the year of collection and in subsequent years as a check on longevity. These germination tests are made mainly in the laboratory, with due precautions to scarify impermeable seed coats and to allow for after-ripening where necessary. Other tests are made in the nursery under more nearly actual range conditions. Finally, both general observations and chart quadrats with supplemental notes are employed to follow the natural reseeding and establishment of the various species in the several range pastures.

Plant Cover Change

Changes in plant cover are followed not only to bring out the principal relationships between vegetation, grazing and weather, but to determine potential range productivity through studies of plant succession and competition. Plant succession is worked out from close study of representative areas on comparable soil types and also from chart quadrats. For example, on clay soils on the Jornada, stages of succession were found from practically bare soil with only scattered lichens to a dense cover of tobosa on more moist sites. Quadrat records demonstrated the actual

invasion of bare areas by burrograss (*Scleropogon brevifolius*), and the competition between burrograss and tobosa grass (**1**). Other successional series have been worked out similarly on sandy soils, the more advanced stages appearing as distance from livestock watering places increased, or in successive years as deteriorated range recuperated from severe drought and overgrazing.

Competition, as a special phase of plant succession, is studied not only by careful observations of number and condition of different species over extensive areas, but also on plots. The behaviour of *Bouteloua eriopoda* and snakeweed (*Gutierrezia sarothrae*), an aggressive low woody perennial, together on compact sandy soils, for example, was studied on three quadrats, each 1 × 3 meters. The plots were established in a fairly dense stand of snakeweed and charted each year, with special records of diameter and height of each snakeweed plant. Supplemental information was obtained from annual records of density and species composition on the surrounding area and on certain other portions of the experimental range. Bisects were made to determine the root habits of both species and the zones of competition for available soil moisture. Altogether sufficient different sets of conditions were compared to indicate the influence which competition, other biotic factors and weather had on survival and reproduction for both species.

Chart quadrats in ungrazed enclosures are used as a check on results obtained on range grazed to various degrees. In laying out enclosures large enough to furnish ample experimental vegetation of the type desired, due allowance must be made for border effects of the fence. In the semi-desert Southwest, enclosures are subject to considerable deposition from drifting windblown sand, especially with rodent-proof fences. It is now a standard practice to build permanent enclosures at least 1 acre in size and, for some studies, considerably larger. The purpose of the enclosure, of course, guides the choice of fence. Barbed wire alone is used to exclude cattle, whereas a mesh wire is necessary to exclude utilization by the smaller rodents such as rabbits and kangaroo rats.

Studies of plant change are amplified with observations and measurements of climatic and edaphic factors. Standard U.S. Weather Bureau instruments are maintained at the Jornada headquarters for measuring precipitation, air temperatures, wind movement, evaporation, and relative humidity. Precipitation varies so greatly between local areas that it is sampled with about eighteen rain gauges located systematically over the experimental range, in addition to several other gauges employed for special studies.

Soil factors are also taken into account in relation to plant change, both as influencing the vegetation and as reflecting the effect of grazing treatment. A soil survey made on the Jornada in 1918 gives a knowledge of general soil-vegetation relationships. Soil conditions are observed, including such features as texture, structure, perceptible moisture, and evidences of wind or water erosion, and recorded every year in the supplemental notes accompanying the charting of each quadrat. Limited detailed studies of soil moisture, physical properties, and chemical analyses of mineral and organic constituents are made as required to explain specific phases of plant behavior.

Grazing Capacity in Large Pastures

With the accumulation of fairly detailed information concerning the important forage plants, the degree of grazing they will withstand, and the seasons of use, there still remains the important task of fitting this information into practical cattle management, especially of working out through grazing-capacity tests the principles for determining proper numbers of livestock to graze on a range unit during suitable seasons or yearlong. Grazing capacity is defined as the number of livestock that can be run successfully on the range year after year during the designated season without injury to the forage or other resources.

The essentials underlying grazing capacity recorded and studied in the Jornada pastures include : (1) the number and condition of livestock ; (2) the annual forage crop ; (3) utilization of the forage crop ; (4) the trend of range condition under the various treatments, and (5) correlation of the preceding items to determine proper stocking in (a) each individual year, and (b) over the period of years, including provision for drought.

Records of numbers of animals in each pasture at all times are of special importance on yearlong ranges where transfers between pastures occur, since they are the basis for calculating the number of animal days of grazing in each pasture. Different classes of animals, such as cows, bulls, steers, and calves, are recorded separately. Condition of the cattle is indicated each month from ocular observations which are supported by actual weights of calves or adult animals sold each year. These livestock records furnish a convincing measure of the results of management, both in the different pasture treatments and on the entire Jornada Range as a practical ranch unit.

The forage crop is the volume of herbage produced that is available to livestock and which can be grazed when the range is properly utilized. It may be expressed on either a relative or absolute basis. On the Jornada Experimental Range the relative percentage of forage produced has been estimated ocularly each fall through a systematic field survey of each type and pasture, and checked against actual measurements of plant area on quadrats and against height growth of important species. It is a present practice to clip and weigh the forage on a number of plots as a check ; there is not at present the available manpower adequately to sample by clipping pastures several thousand acres in size.

Degree of utilization or the amount of herbage grazed is also estimated each year and, as with forage crops, may be expressed on either a relative or absolute basis. On the Jornada Range, utilization is estimated in percentage of the available forage. Ocular estimates are made by species and by types within each pasture during a systematic inspection. The observer practises carefully by estimating utilization on individual tufts of plants and by actual measurements on the quadrats. Utilization inspections are made at first in the autumn when grazing of the matured forage crop is being planned, in December to check range feed available for the next six months, and again late in June just before new growth starts. In a small check pasture of 160 acres, utilization has been estimated recently in absolute terms of pounds per

acre by clipping and weighing plants on pairs of plots, one before and one after grazing.

The trend of range condition, including plant succession and forage production under the various grazing treatments, is obtained from annual inspections, by periodic range surveys, and from the permanent quadrat records. Careful inspection makes use of all the readily available evidence developed by the intensive studies previously described.

The information gathered each year under each of the preceding headings is correlated to determine for that year the suitable stocking or the forage production in terms of animal units for each pasture. It is impossible to stock large yearlong pastures so as to utilize the range exactly to a predetermined degree under widely varying forage production conditions when annual rainfall varies from 3.5 inches to 18 inches, as it has over the last 25 years on the Jornada Range. Moreover, it would have been impracticable to maintain a uniform number of animals in each pasture from year to year. Records of 25 years of grazing, however, closely checked against the several factors of production and use, have given a very good indication of grazing capacity on semi-desert range. With recurrent drought so important a factor, conservative grazing has been shown to be the most stable and productive method of utilizing the best forage, as in the case of the valuable black grama, and furnishing the most economic cattle production. True grazing capacity and proper stocking must be placed at a level considerably below average forage production; on semi-desert range, about 25 per cent below average production.

The application of such conservative grazing and other good management practices on the experimental range has given calf crops half again greater than those on comparable poorly managed range in the same locality, and losses of only one-third as much. The growth of calves and their sale value have also been considerably greater on the Jornada Experimental Range, with correspondingly greater opportunity for profitable beef production.

2. Intensive Pasture Studies on Northern Shortgrass Plains

In contrast to the low grazing capacity of the Jornada Experimental Range is the relatively greater grazing capacity on shortgrass ranges of the Northern Great Plains requiring appreciably smaller areas for ranch operations or experimental work. The range is grazed yearlong by cattle, primarily as a breeding ground as in the Southwest; but winters are very severe and drought is not uncommon. Although average rainfall is only 4 inches greater than at the Jornada, evaporation is less and the rainfall, coming primarily in spring and summer, is more effective for plant growth. Experiments to determine the best utilization for such ranges and its relation to calf production are being conducted at the United States Range Livestock Experiment Station near Miles City, Montana, by the Forest Service in co-operation with the U. S. Bureau of Animal Industry and the Montana State Agricultural Experiment Station.

Twelve pastures are grazed so as to test the value of three intensities of grazing throughout the year. Degrees of use are provided by difference in size of the pastures

to accommodate ten breeding cows and their calves in each lot, duplicated, with 23.1 acres per head in the heavily grazed, 30.5 in the moderately grazed, and 38.8 acres in the lightly grazed group. In the field layout, six pastures were built around one well for summer grazing and a similar group of six pastures at a second well for winter grazing.

Results are measured in terms of both livestock and vegetation. Calf crop in percentage, weights of calves at birth and at weaning, and amount and cost of supplemental feeding, all have clearly indicated the superiority of conservative grazing during the 8 years the experiment has been in progress (**8**). Response of the vegetation to grazing treatment and to climatic factors is followed in the pastures by means of permanent chart quadrats. The point-analysis method, developed in New Zealand, has been used here by Ellison (**6**), employing a mechanically spaced array of needle points projected vertically to the soil surface, and the number of hits on vegetation and ground tallied. These results are supplemented by measurements of height growth and estimates of forage production, utilization, and range trend, throughout the pastures as on the Jornada Range.

The principal difference between the methods applied at this Northern Plains area and the Jornada Range lies in more restricted studies and in carrying the same breeding animals in a uniform number under the same intensity of grazing over a series of years in relatively small pastures set aside for each specific degree of use. Losses in breeding animals are replaced with comparable animals held on other range land grazed to a suitable degree. A similar pasture arrangement adapted to the needs of the central plains area has been established in Northeastern Colorado by the Rocky Mountain Forest and Range Experiment Station, in co-operation with the Soil Conservation Service.

3. Cattle Pasture Experiment in the Annual Plant Type

The problem of grazing breeding cattle on the annual plant type of the California foothills has many different aspects and requires different sampling methods from other western ranges. Introduced annuals now predominate and make their growth mainly in spring after the winter rains. The study aims to determine the time and intensity of grazing that will allow production of the greatest amount of usable range forage each year, especially to furnish a longer season of native grazing than at present, because the annual plants become parched and of low value during the hot dry summer. These and related problems are studied on the San Joaquin Experimental Range, an area of 4,700 acres, in co-operation with the Animal Husbandry Division of the University of California. Duplicate pastures furnish three intensities of grazing, with 160, 240 and 320 acres respectively for heavy, moderate, and light grazing, from the time green feed is available, usually in January, until it dries and loses most of its nutritive value in July or August. Equal numbers of cattle are grazed in each pasture as in the Northern Great Plains experiments, but a special trial is made on supplemental feeding, because of the low nutritive level of the annual plants during the summer and fall. Half the animals in each pasture

are given supplemental feeds only in emergency ; the other half are regularly fed in summer, but also at any other time of year if necessary to keep them in thrifty condition. The cattle are kept in a separate pasture during the months they are not in the six experimental pastures.

Samples of forage representing as closely as possible that utilized by the cattle are collected and analysed for nutritive value for each two weeks' period. The cattle are weighed fortnightly while in the experimental pastures, and results of the various degrees of grazing and supplemental feeding are measured in livestock gains or losses, calf crops, calf weights, and amount of supplemental feed used.

The response of the range itself is unusually difficult to measure because the composition and volume production of the annual plants vary so greatly from year to year, and even from month to month during the growing season (**20**). Inventories are made of the six experimental pastures each year in early summer at the height of forage growth. The individual plants are far too abundant and ephemeral to permit use of the chart quadrat, as with the predominantly perennial grasses of the Northern Great Plains and the Jornada Range in the Southwest. The vegetation is sampled with plots only 1 foot square, randomly located at the rate of one to 2 acres, or preferably one per acre. The forage on each plot is clipped, segregated by main species, and weighed. The trend of the vegetation on the rest of the experimental range is followed with a less intensive sampling by estimate plots. Special enclosures and detailed sampling methods are employed to measure the effect on vegetation of complete protection from grazing and the forage utilization by the more abundant rodent species on the range, such as ground squirrels, pocket gophers, and kangaroo rats.

4. Sheep Grazing Experiments

The sheep grazing experiments of the Intermountain Forest and Range Experiment Station illustrate the need for careful co-ordination of range management research on areas often widely separated. Reflecting the different seasonal sources of forage for range sheep grazing in this region, the Intermountain Station is studying problems of management on high-mountain summer ranges in central Utah, on spring-fall ranges in the high plains of southern Idaho, and on winter ranges in the deserts of western Utah and Nevada. On the pastures of the two latter areas experimental approaches are employed which are rather different from those described for cattle.

Two general differences between range management of sheep and cattle affect the experimental procedure. First is the greater number of animals needed, reflecting the ratio of about three sheep to one cow in range forage requirement, the larger number of animals necessary in an economic outfit, and the greater individual variation encountered over a period of years due to the shorter productive life span of sheep. Second is the strict control exercised over sheep on the open range through constant herding, leading to a more uniform and well managed utilization of the forage than is usually possible with cattle. Because of this, any advantages of improved manage-

ment recorded on small experimental pastures without herding must be carefully checked on herded range. These and other contrasts with cattle experiments are shown in the following examples :

Management of Spring-Fall Ranges

Methods of managing sagebrush-wheatgrass ranges grazed in spring and fall are studied by the Forest Service in co-operation with the Bureau of Animal Industry at the U. S. Sheep Experiment Station in southern Idaho. The purpose is to determine the best seasonal management and intensity of stocking consistent with maximum production of usable forage and of mutton and wool.

Specifically, the rotation system is tested against the rotation-deferred system and continuous grazing in moderately grazed 80-acre paddocks. In the rotation system the 2 months spring grazing is so rotated among a series of four paddocks that each is grazed during the same 15-day period only once in 4 years ; and the fall grazing is similarly rotated. In the rotation-deferred system each paddock in the series is completely deferred until fall once in 4 years.

In addition to the tests of moderate use, the rotation system is tested under light and heavy grazing in 40-acre paddocks. The different intensities are attained by stocking at 8, 12 and 16 sheep-days per acre in spring and again in fall. The animals grazed in the experimental paddocks are run with the regular Sheep Station herds during the rest of the year, on mountain range in summer, and in winter either run on desert range or fed. The dual season of grazing and the complexity of the management systems being tested in this experiment show a sharp contrast from the year-long and winter-spring cattle grazing arrangements previously described.

Results of treatments are measured both in terms of the livestock and of the vegetation. Sheep records include body weights of mature ewes before and after both spring and fall grazing, the number of lambs born, and the weights of lambs at birth and weaning. The weights of fleeces at shearing furnish an additional consideration not available in the cattle experiments.

The measurement of results on the vegetation is made difficult by the fact that the main growth occurs during the spring grazing season. Furthermore, the forage crop is so heterogeneous in growth form, with approximately 14 per cent shrubs, 58 per cent grasses, and 28 per cent weeds, that the sampling problem is different from that of the predominantly perennial grasses of the Northern Plains and the Jornada and the annual plants of the California foothills. Chart quadrats and general estimates of forage production and use, checked by sheep-days feed obtained, were employed to follow the vegetative response in early studies (**5**). In studying shrubs too large for meter quadrats, such as sagebrush (*Artemisia* spp.), Pickford and Stewart (**16**) mapped plots 5 by 20 feet in size with the co-ordinate method. A crossbar was suspended from two parallel steel tapes located on the sides of the plots ; the mapper recorded the intersection of the bar with each shrub, then moved to the next interval on the steel tapes.

More recently, Pechanec and Pickford (**13**) have developed the method of

estimating directly the forage weight on plots, overcoming many of the disadvantages of general estimates of forage production. At the beginning of an experiment to extend through several years, an inventory of productivity is made by estimating forage production by species on temporary plots, either randomized or in a gridiron. A number of plots are marked permanently for annual estimates. In determining forage production, the estimator trains and accurately checks his estimates regularly by clipping and weighing the plants on a few test plots. Particular care is necessary on the sheep range to include only forage available to sheep, eliminating from the estimate forage plants protected from grazing by the abundant sagebrush. Circular plots of 50 and 100 square feet have been used ; the smaller plot has proved better suited to this type of range. If forage production is being determined on grazed range, the herbage on the ground is estimated, the utilization percentage recorded, and the weight of forage calculated accordingly. To preserve ungrazed plant material for sampling, small temporary enclosures are erected in the paddocks grazed during the growing season. These enclosures are moved each year to avoid cumulative effects of protection.

The ocular plot-estimate method of determining degree of utilization has also been applied on this range (**14**). Utilization of each species is estimated on plots as indicated above. Training is based on ungrazed plants clipped to simulate grazing ; estimates of utilization for each species are made and the residual herbage is clipped so that the observer's estimate of percentage removal is checked against actual weight.

As a final step in the research, the conclusions drawn from the small experimental paddocks are studied under practical range conditions with herding on the entire Sheep Station area of over 12,000 acres, which is grazed conservatively during both spring and fall.

Economic Sheep Grazing on Desert Winter Range

The winter-range phase of sheep raising in the Intermountain Region is being studied at the Desert Experimental Range in western Utah. The purpose is to develop methods of managing winter ranges in as highly productive condition and for as long a winter season as practicable. The studies on the 55,000-acre range aim to determine the effects of late fall, winter, and early spring grazing upon forage productivity under different intensities of grazing. These three seasons and their three two-way combinations are set up in a factorial experiment with light, medium, and heavy intensities of utilization in eighteen pastures, each 320 acres in size. The animals are unherded in the pastures and are selected from two privately owned bands of sheep, each of which alternates between the general herded pastures of the conservatively grazed Desert Experimental Range and the heavily grazed outside range. The two alternating bands provide an excellent basis for comparison of the economic benefits of good management on the experimental range with the results of usual practices on outside range.

There are many points of difference between the desert winter range and the

spring-fall range on the Sheep Station in Idaho. The precipitation on the desert is more uncertain and nearly one-fourth less than the 10 inches received on the spring-fall area. The desert vegetation is more sparse, hence a greater area is required to support an animal. Furthermore, the winter grazing season begins only after forage growth is completed and the sheep usually leave for spring range before new growth begins on the desert. In addition, the forage is made up mainly of perennial grasses and low palatable shrubs. These features permit much more satisfactory records of the vegetation and its changes than at the Sheep Station where spring grazing coincides with the main growing season.

Inventories are made of forage production each year after growth is complete but before grazing starts, both in the herded area and in the smaller pastures. A volume estimate method is used on plots which, because of the sparse vegetation, are 200 square feet in size in contrast to the 50 square feet employed in the weight estimate method on spring-fall range. After the current year's forage production has been removed and has been measured by species in cubic feet on several plots to train the observers, enough additional plots are systematically estimated to furnish a predetermined sampling accuracy. Degree of utilization in each pasture and on the herded range is determined in the same manner in volume after the sheep have moved away from the desert range. The close correlation between volume and weight of this desert forage permits ready conversion of data into weight if desired.

Forage production from year to year is one measure of the effect of grazing treatments in the pastures, supported by permanent chart quadrats to show changes in stand and the response of individual plants. Complete records of livestock—animal days feed obtained, lamb crops, weights, wool clip, and supplemental feeding required—also show the practicability of the grazing treatments in pastures on the herded experimental range, and on the heavily grazed outside range.

5. Ecological Studies on High Mountain Summer Ranges

The research on management of ranges to furnish livestock grazing throughout the year in the Intermountain region is completed by the studies on high mountain summer ranges at the Great Basin Branch Station in central Utah. This historical area, established in 1912 as the first experimental range of the Forest Service, is located on the Manti National Forest, where many different combinations of range vegetation, soil and moisture, altitudinal zone, and degree and season of grazing by cattle and by sheep are available for comparison. The investigations are primarily ecological, aimed at determining the proper time, degree, intensity, and frequency of grazing on these summer ranges, in accordance with the growth requirements and natural revegetation of the important forage plants. These pioneer studies have been the foundation for much of the range ecology work in the West, both as to methods, and as to basic principles.

The problem differs from all those previously discussed in that the grazing is limited to the late spring and summer, coincident with the active growing season of the vegetation; the forage types are intermingled with stands of oakbrush or open forest, often on slopes so steep that satisfactory grazing is very difficult to attain.

Furthermore, the summer range studies are mainly on the open range, with numerous enclosures to furnish ungrazed plants for detailed observation, and with temporary, movable panels to provide plants grazed at definite times and intensities. Certain management systems are been tested in paddocks, and a few small pastures have been grazed in connexion with special studies of artificial revegetation and watershed management.

The research program includes the following phases under range management investigations: (1) the effect of climate on plant growth, (2) range readiness and season of grazing, (3) natural revegetation, and (4) season and degree of grazing as related to range productivity. In addition to these range management phases, there are closely correlated studies of artificial revegetation, watershed protection, and biological influences.

Contributing to the entire ecological work is the series of climatological stations ranging from 7,655 feet in the oakbrush zone through the aspen-fir at 8,850 feet to the spruce-fir zone at 10,100 feet elevation. These weather data, in conjunction with measurements of plant growth and development, have furnished reliable information on grazing periods (**4, 19**).

In order to determine the time when the range is ready for grazing, plant development observations were made on numerous species, including grasses, broad-leaved herbs, shrubs, and aspen. Conditions represented involve several different elevations, exposures or directions of slope, and degrees of slope. Conducted over a period of years, the study has shown the normal trend and fluctuations in seasonal development as influenced by climatic factors under various site conditions, in relation to best seasonal management.

Studies of range-plant succession and natural revegetation have developed principles of far-reaching importance in management to restore depleted range. Observations of plant and soil conditions over the years on areas ranging from seriously disturbed to highly productive types, supported by chart quadrat records, revealed the stages of plant succession, and the conditions of soil, moisture, slope, exposure, and grazing associated with or responsible for each stage, or for change (**18**). Studies over a long period on permanent chart quadrats are used to show the slow progress of succession on depleted soils. Changes in plant cover under various conditions of habitat and grazing use are also determined from permanent major plots, varying in size from 0.5 rod square to 50 feet square as necessary to include suitable vegetation for observation. The vegetation on these plots is mapped periodically, supplemented by reconnaissance notes of density, composition, forage production, and utilization.

Discussion of range management research on summer ranges is incomplete without a reference to the earlier work of Sampson, dating from 1907 in Oregon, on life histories and forage values of important range plants (**17**). Habitat conditions and growth stages were observed in the field, and ecological requirements such as soil and moisture preferences and drought resistance determined through wilting tests worked out. This type of work is now handled largely under range forage investigations. After a lapse of several years, range research in Oregon and Washing-

ton was revived in 1936, under the Pacific Northwest Forest and Range Experiment Station. Preliminary studies of management on national forest summer ranges have progressed to the point where more intensive work in pastures is being organized.

6. Correlation of Grazing and Timber Reproduction

Some 126 million acres of the western range are on open forest land, which produces both valuable forage for summer grazing and commercial timber. In this type it is important for grazing to be managed with the minimum of damage to the forest resource. A study of the harmonization of cattle grazing with timber growing is conducted by the Southwestern Forest and Range Experiment Station in the ponderosa pine forest of northern Arizona. It aims to determine the susceptibility of pine seedlings of various ages to injury ; the relationship to such injury of range forage utilization and of other agents such as insects, small rodents, game animals, fungi, frost and drought ; the processes of seedling recovery from injury ; and finally the practical range and livestock management needed to reduce grazing injury to a minimum.

The conditions under which grazing damage occurs to ponderosa pine seedlings and the effects of such damage are studied in a large pasture of 24,000 acres grazed by about 1,000 steers, during a five-months' season from June to October inclusive. Observations are made on rectangular plots, varying from 300 to 400 square feet in area, selected to obtain a large number of plants under conditions varying from thin to dense reproduction, different plant types, zones of forage utilization, intensities of injury, and availability of water. Movable panel enclosures are employed to control time and intensity of grazing on selected areas of from 1 to 4 acres. Germinating seedlings are so numerous in some years and die so rapidly from various causes that those less than 2 months old and in the cotyledon stage are simply counted on each plot. Older, well-established seedlings are tagged and indicated on plot maps. Damage from other agencies is carefully recorded before grazing begins each year, and insofar as possible while grazing prevails. Repeated observations are made on the plots during the grazing season to note the kind, amount, and cause of damage to individual seedlings, along with possible correlated factors such as stage of development, succulence, and utilization of the forage plants, precipitation and other climatic factors, and physical conditions of soil and vegetation. Recovery of damaged seedlings is followed both on the plots and on especially selected individual seedlings. Method of recovery and growth are worked out both from gross observation in the field and morphological studies of prepared material in the laboratory.

Finally, the plot data, supplemented by careful observations throughout the pasture, permit determination of the management features that reduce grazing damage to the pine seedlings, such as location of water and salt, and fencing.

A somewhat similar study is conducted in the Sierra Nevada by the California Forest and Range Experiment Station, in the ponderosa pine—sugar pine type. Emphasis here is mainly on a comparison of forage values obtained from open forest range before and after logging, as grazing damage to tree seedlings is negligible.

7. Importance of Fundamental Research

Many additional types of range problems and research approaches might be cited. The methodology of research on artificial revegetation of range lands, and the study of range watershed management each deserve separate treatment. Underlying the more diverse practical experiments aimed at specific management problems, however, there is the need common to all lines of range research for fundamental ecological and physiological investigations. An example will indicate the necessity and value of basic investigations in explaining some of the more intricate relationships of range plant growth.

The high mountain summer ranges in central Utah are in great demand for as long and intense a grazing season as they will stand. In working out the growth and nutritional requirements of the plant itself as a basis for better planning of the permissible season and degree of grazing on such ranges, McCarty (**9**) determined the relation of growth to the varying carbohydrate content in mountain brome throughout the year at the Great Basin station.

Samples were taken from an area of about one-sixth acre within an enclosure seeded to mountain brome several years before. Collections were made at random in the morning at 10-day intervals during the snow-free period and monthly during the winter. A 40-gram sample of stem bases and roots was obtained from six to ten plants, which yielded an adequate sample of herbage, consisting of stems and leaves. The samples were cleaned and preserved in 95 per cent alcohol in the field. Later, in the laboratory, standard methods of chemical analysis were used in determining reducing and total sugars, starch, and hemicellulose. Along with the collections of plant material were taken growth measurements and dates when important growth stages were reached. McCarty's results over a 3-year period indicated the importance of relatively high concentrations of sugars in the basal organs of mountain brome in resistance to low temperatures and to winter survival.

A subsequent 4-year experiment on meter quadrats tested the effect of various clipping treatments on carbohydrate storage and plant growth.

In the early days of range research there was a great deal of empirical study and considerable valuable information was obtained in that way, but the complex nature of the problems demands a more intensive approach along fundamental lines. The 1939 Range Research Seminar (**21**), with an attendance of sixty members of the Forest Service, attests the growth and interest in the work in the United States. Permanent committees were appointed on methodology and terminology. It has already been proposed to hold another seminar within the next few years open to all range ecologists. The numerous foreign visitors to the United States and the more frequent exchange of methodology between workers on different continents through published channels definitely stimulate better research. Opportunities for improvement in methods are great, especially as ecologists adopt more efficient, modern statistical designs and co-ordinate work with other fields such as physiology, biochemistry, soil science, and similar studies.

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GENUINENESS OF TYPE IN RED CLOVER

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[Translator: R. Peter Jones]

In Swedish hay leys, red clover occupies a very prominent position. Three different types are distinguished according to the degree of earliness of the plants. The time of flowering and withering of the flower-heads is used as an expression of this. In State sealing from July 1, 1937, after-control cultivation at the State Seed Testing Station to determine genuineness of type of the seed lot has been obligatory. As check varieties for the various types may be mentioned Essi for early red clover, Harrie for medium-late and Göta for late red clover.

In the south of Sweden recently there has been a growing tendency to sow medium-late and early types, as leys of shorter duration are now employed there. In the southerly parts of middle Sweden, for example in Östergötland, both late and medium-late types are cultivated. In the greater part of Middle Sweden and also in Norrland, where the leys are often left down for three or more years, the more hardy late red clover predominates. The medium-late types give in general a good yield in the first year with, as a rule, abundant aftergrowth, but on the other hand a poorer yield the second year, and in the third year ley only a small amount of red clover is present in comparison with leys sown with the more persistent late red clover.

It is consequently of great economic importance for agriculture that red clover of the right type should be used and the guarantee of genuineness of type which is now prescribed for State sealed red clover signifies a great advance. The results of after-control cultivation carried out with the samples which represent sale during the period 1937-8, the first season the new sealing regulation was applied, are briefly reported below.

In the spring of 1938 there were sent in for after-control cultivation 188 samples of type-labelled lots of red clover only. As is seen from the accompanying statement, 43 samples came from firms in south and 145 samples from firms in middle Sweden. No samples were received from Norrland and consequently no State sealing of red clover took place in that part of the country. Twenty-nine samples were labelled early, 22 samples medium late, and 137 samples late red clover. The early and the medium-late red clover derived mainly from south Sweden while the major part, or 94 per cent, of the lots of late clover were sealed in middle Sweden.

Of the 43 lots State-sealed in south Sweden only two proved to be not true to type, namely, one lot of early and one lot of late red clover. Of the 145 samples, mainly late red clover, from middle Sweden, 39 could not be certified as true to type; this amounts to 27 per cent of the total number of samples.

*Hellbo, E. Rödklöverns typäkthet. [Genuineness of type in red clover.] *Svensk Frötidn.* 8. 121-4. 1939.

Comparison of results of after-control cultivation of type-labelled lots of red clover State-sealed during the season 1937-8

Type description	South Sweden			Middle Sweden		
	No. of samples	True to type	Not true to type	No. of samples	True to type	Not true to type
Red clover, early	26	25	1	3	3	—
Red clover, medium-late ..	9	9	—	13	8	5
Red clover, late	8	7	1	129	95	34
Total	43	41	2	145	106	39

The reason why it may not have been possible to certify a sample as true to type may in part be due to the fact that this in its entirety is composed of another type or further that the content of plants of another type was too high. In some cases samples have consisted of mixtures of all three types.

As regards control cultivation it must be pointed out that all the samples were sown both at Bergshamra near Stockholm and at Alnarp in Scania and on two plots at each centre. The samples were judged on a large number of occasions both in the autumn of 1938 and in the summer of 1939.

Distribution of the samples in the different parts of the country took place according to the situation of the firms. This does not necessarily imply that seed production took place in the district in question, but as a rule such was the case.

In Östergötland at present seed of all three types is produced. For a long time seed production of late red clover has been practised there, but some years ago seed production of medium-late red clover was initiated particularly in the western parts of the province. The Danish variety Hersnap is grown, probably not least on account of its high seed yield. But during the last few years seed production of the early variety Essi has also been carried out on a large scale in Östergötland.

Such a state of things is not calculated to preserve uniformity in this province which is of such great importance for seed production. Of the samples of late red clover sent in during the above-mentioned period from Östergötland, 54 lots were sealed under this description and of these only 28 samples could be certified as true to type. The other 26 samples had either been more or less seriously adulterated with the medium-late or early type or in a few cases were composed altogether of another type. The risk is of course greatest where such lots are sold to areas where *late* red clover should be grown.

It is in the interest of seed production and the seed trade to introduce order into this state of chaos. It is necessary in the first place to find the cause. Hitherto the variety Hersnap has indisputably been responsible for the most serious confusion. This variety is referred to in Denmark as "late," that is to say, late red clover. This applies again for the rest to most Danish varieties with the same description. They are not of the type considered to be late in Sweden, but are throughout decidedly earlier. When Hersnap was introduced into Sweden, it was probably believed that

this variety in its degree of earliness ranked with Swedish late red clover. In support of this assumption a concrete example can be mentioned. Some years ago a firm in Östergötland sent a sample of Hersnap to the Central Seed Testing Station labelled late red clover in order to prove both to itself and the Institute that such was the case. The reply received, however, was to the effect that the sample was of medium-late type and resembled the Danish variety Hersnap. Undoubtedly Hersnap has to a large extent been sold as late red clover and many growers in good faith grow it for seed and sell it as such.

Another reason is to be looked for in the technique of seed production. In seed production of early red clover, a cut is taken from the seed field during the early part of the summer, and seed is afterwards harvested from the aftermath. By adopting this procedure two advantages result. In the first place the earliness of the variety or strain is maintained, as the early types give the quickest and most vigorous after-growth, while the late types are impeded, and in the second place flowering is post-poned to a time when humble bees and honey bees occur in larger numbers. On the other hand if a seed crop of medium-late and late red clover is taken from the after-math stand, the early types are encouraged and the progeny is shifted for each seed generation more and more in the early direction. Probably this affords an explana-tion of the fact that Hersnap, for example, in many cases in degree of earliness shows a tendency to approximate to early red clover. When compared with a standard sample received from a reliable quarter in Denmark, Östergötland-grown Hersnap has very frequently been decidedly earlier, which would not be expected if the correct method of seed production had been employed. Further, if a lot of late red clover mixed with medium-late or early red clover is used for aftermath cultivation, it will be realized for the reason just mentioned that the type late red clover in time is super-seded. The writer is of opinion that the circumstances mentioned are responsible in a large measure for the unfavourable results obtained from Östergötland after-control plots.

The risk of crossing must also be taken into consideration. In this connexion the seed growers' associations have an important duty to perform and one might almost wish that in regard to seed production of meadow plants regulations were in force similar to those introduced by the Scanian Seed Growers' Association and the South Kalmar Seed Growers' Association with reference to the cultivation of root crops. There is no doubt that the seed growers' associations in collaboration with the field control department of the State Central Seed Testing Station could do a great deal to bring it about that seed production of red clover should be conducted more systematically, to the advantage not only of seed production, but also of the seed trade.

It should be pointed out in this connexion that in various parts and not least in Scania a large number of seed growers have adopted State sealing with controlled cultivation certificate of *inter alia* red clover seed. In this process the seed to be sown is subjected to seed control cultivation, the seed field is inspected during the growing season, and the sealed commodity is subjected to after-control cultivation. It would undoubtedly be a great advantage if in different districts at least some seed

growers, possibly contract growers, applied such control. Such farms would then serve as cultivation centres where the different varieties and strains would be maintained in their original type. From these centres individual growers time after time could obtain new and reliable seed grain for their seed plots.

The seed growers' associations should make a list of the red clover material cultivated in their areas. Some years ago the Seed Growers' Association of the province of Stockholm, in collaboration with the State Central Seed Testing Institute, arranged for the preparation of such an inventory in that province. The result was more satisfactory than was anticipated in that altogether about one hundred of the samples proved to be of the pure late type.

Only by close collaboration between growers, seed growers' associations, seed control and the trade can a satisfactory solution be found.

URUGUAYAN RESEARCH ON FORAGE PROBLEMS

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The overwhelming importance in Uruguay of stock-raising, and consequently of maintaining and perfecting the country's capacity for producing forage, in itself indicates the forage problem as a theme of special interest, towards which contemporary research increasingly gravitates. The following statistics are sufficient to give an exact idea of the economic structure of Uruguay in relation to its general output of animal products. Of the 190,000 square kilometres which represent in round figures the total area of the country, 1,322,780 hectares, or approximately 7 per cent, were devoted to arable cultivation in the five-year period 1933-34 to 1937-38. The number of persons occupied in agriculture during the same period was 101,566, or 5 per cent of the total population, which numbered 2,093,331 on Dec. 31st, 1938. While recognizing the special importance of agriculture in the economic life of every land and therefore in that of Uruguay also, the greater significance of stock-raising for this country is even more evident when it is considered in relation to world economics.

The total of $90,124,305, which represents in Uruguayan currency (pesos) the mean value of the country's exports during the five-year period 1934-38, is divided in accordance with different categories as follows:

	Per cent
Stock-raising and derived industries	81
Arable farming and derived industries	12
Extractive industries and their derivatives	5
Various articles	0.8
Provisions for shipping	0.4
Coal for shipping (only in 1937-38)	0.8

While the marked preponderance of stock-raising in contributing to the country's exports gives an idea of its importance in comparison with the other lines of production, I should like also to add the final figures of the last cattle census (1937) as an index of the absolute volume of stock-raising in Uruguay. There existed in that year the following numbers of animals:

Cattle	8,226,890
Sheep	17,931,327
Horses	644,200
Mules and asses	10,915
Goats	28,129
Pigs	346,329
Total	27,187,790

Comparing these data with the corresponding figures for area (190,000 sq. kilometres) and population (2,000,000 inhabitants), it is evident that Uruguay occupies, both per inhabitant and per unit area, one of the foremost positions among the stock-raising countries of the entire world. The economic life of the country rests mainly upon this production of cattle, so important through the exportation of meat, wool, horns and other products of the meat-freezing industry. Dairying has not passed beyond the initial stages, and does not yet participate to any appreciable extent in the export trade. The early publications, therefore, were entirely justified in describing Uruguay as a stock-raising country *par excellence*.

It is thus readily comprehensible that in the previous century, when scientific observation was first begun, in making an inventory of the natural sources of production attention should have been devoted to one of the fundamental aspects of the country's productive potentiality, although without proceeding to investigations expressly designed to maintain and perfect it (improvement of natural grasslands, control of weeds, soil conservation, application of fertilizers, etc.). I refer to the study of the immense open grazings, or campos, by means of the identification of the grasses and other herbage species composing them. Just as the register of the plant resources of Brazil was initiated through the classification of its incalculable forest riches by Martius and collaborators, whose "Flora Braziliensis" represents an inventory of singular value from the scientific viewpoint, so the naturalists of the nineteenth century accumulated data on the predominant flora of Uruguay, namely, the grasses and other plant species composing the spontaneous vegetation of the vast open grassland plains or pampas. The bibliography appended to this paper notes the principal sources of information concerning this aspect of the Republic's natural resources. Nevertheless, attempts to arrive at a more perfect utilization of the land and, consequently, at a better conservation and even amplification of the country's natural resources through the practical application of scientific research to forage problems, belong to a very recent date.

Without failing to recognize the merits of the early work leading to this end, there must be noted the impulse which such research has received within the last few years as a result of the creation in 1935 of the National Commission for the Study of the Forage Problem. This was inaugurated on the initiative of Don César G. Gutiérrez, then Minister of Agriculture, and his action has already been justified by the work carried out by the Commission, over which the author of this paper has the honour to preside. A statement of the aims and programme of the Commission, which is responsible to the Ministry of Stock-raising and Agriculture, is available in one of its publications (1936), translated into English by G. M. Roseveare. In a more recent publication, Boerger (1939) adds some detailed information concerning its working, at the same time giving the names of its present collaborators and of the scientific staff employed.

The creation of this Commission undoubtedly marks for Uruguay the beginning of a new stage of progress in regard to everything connected with forage questions. For this reason the bibliographical material appended to this paper has been grouped

in two parts, comprising respectively work published before and after the creation of the Commission.

It is not my intention to give detailed information on the investigations concerned, but simply to call the attention of those interested to the importance of the work already done and in course of execution. The bibliography constitutes an eloquent proof of the seriousness with which Uruguayan workers have approached their task. The present list is confined to Uruguayan work, although in the neighbouring countries likewise, Argentina and Brazil, an increasing amount of attention is being devoted to this class of research. Within all three countries variation of soil and climate is so marked, that the usefulness of the practical solutions obtained from forage research is necessarily restricted to limited areas within these vast territories.

Among the foremost problems arising in Uruguay is that of the necessity of reinforcing the production of the natural pastures, generally sufficient and even abundant in the spring and autumn, by the growing of forage plants in order to feed cattle adequately, and to fatten them also, in periods of scarcity. These periods of scarcity and, at the worst, of dearth, occur in consequence of low temperatures in the winter and again from the intense heat and more or less prolonged droughts of summer. Hence the great importance of the investigations concerned with forage cereals, or plants which are normally used for grain production, with a view to obtaining sown leys. For this purpose oats are of the most importance under conditions in Uruguay, followed—in order of distribution and importance—by barley, wheat and rye, all destined for the production of green feed in the winter.

Similar use, for summer grazing, is made of different species of sorghum, especially Sudan grass (*Andropogon sorghum* var. *Sudanensis*), followed in importance by maize and, in isolated cases, by other species such as *Pennisetum purpureum*, *Chloris gayana*, etc. Since all these cultures without exception consist of grasses, endeavours are being made to perfect them by means of an admixture of legumes suitable for growing in the cold or hot seasons respectively. Detailed information on these problems is accessible in the publications dealing with them. In connexion herewith some entomological studies affecting the forage cereals are of interest, such as, for example, those on *Toxoptera graminum* Rond., whose epidemic incidence in the years 1937 and 1939 seriously affected, among other crops, the winter leys composed of fodder cereals.

The agrological difficulties opposing a general extension of lucerne-growing in Uruguay, unlike the Argentine Republic in this respect, necessitate many specialized investigations to which attention should be drawn.

A third group of studies seeks to elucidate the problem of forage foresight, and has recently obtained some satisfactory results, mainly through ensilage.

Experiments in the fattening of calves and capons, in the economic feeding of dairy cows, and on other purely nutritional questions are also frequently undertaken.

Much research is related to soil deficiencies which in their turn provoke defects in the animal organism, such as osteomalacia, rachitis and osteoporosis, all of which have been the subject of more or less prolonged investigations.

In their direct connexion with the problem of the improvement of the natural grasslands, negative aspects are likewise studied : distribution of undesirable plant species, including weeds and poisonous plants, in the first place, and then impoverishment of the soil by the removal of calcium, the diminution of phosphorus content, etc. And, last but not least, there is the problem of erosion and questions related to it, problems which constitute an increasingly general subject of investigation, not only in the new countries of this Continent, but in other lands also, so that " Conservation" has been chosen by the organizing committee of Section IV, Agriculture and Conservation, as its special theme or the culminating point towards which all the investigations and publications of the Section are to converge.

From the historic viewpoint, special attention should be drawn to the information on the beginning of lucerne cultivation after its introduction into Uruguay in 1776, accessible in the work of Pérez Castellano. The first information on the grasses of Uruguay is due to Larrañaga, and all investigations of this nature were then gathered up into the classic works of Arechavaleta, which form the basis of all subsequent research on the subject.

Of publications belonging to the period preceding the creation of the Forage Commission, special mention should be made also of the work of Mariano B. Berro on the grasses of Vera and the investigations of Van de Venne on fattening in the open grasslands, this last-named article being of particular importance as the starting-point of the most recent work on this aspect of the Uruguayan forage problem.

Although, from 1935 onwards, the National Commission for the Study of the Forage Problem constitutes the organization about which the investigations carried out by various State institutions are centred, such as, for example, the Faculty of Agronomy, the Experiment Station of the Department of Stock-raising, the Department of Agronomy, the Official Seed Distribution Service, and the Plant Research Institute and National Seed-testing Station of La Estanzuela, there are carried out, happily, many other investigations independent of the Commission, as is seen from a survey of the appended bibliography. While recognizing the merits of all the work that has been listed, I have pleasure in referring especially to the thorough investigations of Messrs. Gallinal, Bergalli, Campal, Aragone and Rosengurtt, condensed in the publication " Studies on natural meadows of Uruguay ", 1938.

What has been said in the foregoing paragraphs will be sufficient to afford to those interested a general indication of Uruguayan research in this branch of specialization. The following bibliography, which forms an integral part of my report, will enable immediate recourse to be made to the more detailed information available in the publications themselves.

CHRONOLOGICAL LIST OF PUBLISHED WORKS RELATING TO THE FORAGE PROBLEM IN URUGUAY*†

I. Works published prior to the formation, in 1935, of the National Commission for the Study of the Forage Problem

1776-1814

PÉREZ CASTELLANO, J. M. Observaciones sobre agricultura. [Observations on agriculture.] Published in 1848 ; reprinted Montevideo, 1914. pp. 608. This work, written in 1813-14, contains in " Observations " Nos. 399-404 valuable data on lucerne, first cultivated in Uruguay in 1776.

1804-1848

LARRAÑAGA, D. A. Work by Dámaso Antonio Larrañaga, published by the Instituto Geográfico del Uruguay, Montevideo, 1922-23. See Vol. 2. Botánica. pp. 1-293.

1820

ST. HILAIRE, A. Nota sobre un trébol semejante al *Trifolium subterraneum* encontrado en 1820 cerca de Colonia. [Note on a clover resembling *Trifolium subterraneum* found near Colonia in 1820.] Letter from St. Hilaire to Larrañaga. Works of Dámaso Antonio Larrañaga. Edn. Nacional. 1923. Vol. 3. p. 277.

1873

GIBERT, E. Enumeratio plantarum sponte nascentium agro montevidensi. *Revista Asociación Rural del Uruguay.*

1882

CARAVIA, A. T. Manual práctico del cultivador Americano. [Practical manual for the American farmer.] Montevideo, 1882. pp. 500. (Isolated data on some forage plants.)

1894

ARECHAVALETA, J. Las gramíneas Uruguayas. [The Uruguayan grasses.] Montevideo. 1894-97. pp. 550. pls. 71. figs. 15. (A complete edition of this work, which was originally published in six fascicles from 1894 to 1897, appeared in May, 1898. This point is of importance in order to avoid discrepancies in paging when references are given.)

1898

ARECHAVALETA, J. Las gramíneas Uruguayas. Tercera parte. Agrostología aplicada. [The Uruguayan grasses. Part 3. Applied agrostology.] *An. Mus. Hist. nat. Montevideo.* 4 (1). 87-122. 1898.

1898-1911

ARECHAVALETA, J. Flora Uruguaya. 4 vols. *An. Mus. Hist. nat. Montevideo.* Vols. 3, 5, 6 and 7.

1899

ARECHAVALETA, J. Contribución al conocimiento de la flora Uruguaya. [Contribution to the knowledge of the Uruguayan flora.] *An. Mus. Hist. nat. Montevideo.* 2 (12). 273-87. 1899.

BERRO, M. B. La vegetación Uruguaya. [The vegetation of Uruguay.] *An. Mus. Hist. nat. Montevideo.* 2. 89-196. 1899.

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*This bibliography also, the first part of which contains amplifications and corrections of the analogous list published in 1935 [*Propaganda Rural, Montevideo.* Nos. 783 and 784. 1935], is necessarily incomplete because it has not been possible for the author to consult all the series of reviews, etc., many of them entirely out of print, in which communications of this nature were dispersed in earlier times, when publishing organs of a strictly agronomical character were lacking. Although it is not probable that work of importance has been omitted, the author would be grateful for any corrections or supplementary data sent to him.

†[Where references contain figures in round brackets, these refer to parts of periodicals.]

1901

SPEGAZZINI, C. Stipeae Platenses. *An. Mus. Hist. nat. Montevideo.* 4 (2). 1-173. 1901.

1905

ALVAREZ, T. El cultivo de la alfalfa. Rendimiento, valor alimenticio, análisis de sus diferentes partes, enfermedades y medios de combatirlas. [The cultivation of lucerne. Yield, nutritive value, analysis of the different parts, diseases and means of controlling them.] Montevídeo, 1905. [Agricultural pamphlet.]

ARECHAVALETA, J. Breves apuntes sobre algunas gramíneas de propiedades tóxicas para los herbívoros. [Short notes on some grasses having properties toxic for herbivora.] *An. Mus. Hist. nat. Montevideo.* II. 1 (2). 47-57. 1905.

1906

ALVAREZ, T. Agricultura general. [General agriculture.] Montevideo, 1906. pp. 409. (Pages 339-97 are devoted to the agriculture of forage crops.)

BERRO, M. B. Las gramíneas de Vera. La enumeración, clasificación y utilización forrajera. [The grasses of Vera. Enumeration, classification and use as forage.] Montevideo. 1906. pp. 120.

1907

BACKHAUS, A. Cultivo de forrajes en el Uruguay. [Cultivation of forage plants in Uruguay.] *Rev. Secc. Agron. Univ. Montevideo.* (2). 1-18. 1907.

SCHROEDER, J. Las plantas forrajeras del Uruguay y su valor para la alimentación del ganado. [The forage plants of Uruguay and their value for the feeding of stock.] *Rev. Secc. Agron. Univ. Montevideo.* (2). 86-103. 1907.

VENNE, H. van de. Las bases científicas de la producción vegetal y su relación con la ganadería. [The scientific bases of crop production and their relation to stock-raising.] *Rev. Secc. Agron. Univ. Montevideo.* (2). 47-72. 1907.

1908

DAMMANN, H. Ensayos sobre gramíneas y leguminosas cultivadas por separado ; ensayo sobre el valor de cultivo de gramíneas y leguminosas en mezclas. [Trials of grasses and legumes grown in pure cultures ; experiment on the value of grasses and legumes grown in mixtures.] *Rev. Secc. Agron. Univ. Montevideo.* (3). 25-40. 1908.

——————— Ensayos de cultivo. Ensayo para determinar el valor de cultivo de diferentes clases de remolachas forrajeras. [Cultivation trials. Trial for determining the value of different classes of fodder beet for cultivation.] *Rev. Secc. Agron. Univ. Montevideo.* (4). 209-13. 1908.

GASSNER, G. Algunos análisis de semillas. [Some seed analyses.] *Rev. Inst. Agron. Montevideo.* (4). 107-15. 1908. [Deals with different varieties of lucerne.]

SCHROEDER, J. Estudios y trabajos del laboratorio de química general y agrícola. I. Las plantas forrajeras del Uruguay. II. Resultados de análisis. [Studies and work of the Laboratory of General and Agricultural Chemistry. I. The forage plants of Uruguay. II. Results of analyses.] *Rev. Secc. Agron. Univ. Montevideo.* (3). 119-41. 1908.

1909

DAMMANN, H. Ensayos de cultivos con remolachas forrajeras y azucareras. [Trials of fodder and sugar beets.] *Rev. Inst. Agron. Montevideo.* (5). 213-21. 1909.

GASSNER, G. Algunos análisis de semillas. (Continuación : alfalfa, gramíneas y tréboles.) [Some seed analyses. (Continuation : lucerne, grasses, and clovers.)] *Rev. Inst. Agron. Montevideo.* (5). 95-105. 1909.

1909—(continued)

SCHROEDER, J., and DAMMANN, H. Ensayos de cultivo de plantas forrajeras. [Forage plant trials.] *Rev. Inst. Agron. Montevideo.* (5). 222-38. 1909.

———————— Ensayos de cultivos con diferentes abonos fosfatados. (Remolachas forrajeras.) [Trials of different phosphatic fertilizers. (Fodder beet.)] *Rev. Inst. Agron. Montevideo.* (5). 239-42. 1909.

VENNE, H. van de. Los residuos alimenticios de la Distilería Oriental de Montevideo. [The nutritive by-products of the Oriental Distillery, Montevideo.] *Agros. Montevideo.* I. 1 (6). 154-8. 1909.

1910

DAMMANN, H. Ensayos de cultivo con plantas forrajeras. [Forage plant trials.] *Rev. Inst. Agron. Montevideo.* (7). 201-12. 1910.

———————— Sobre el cultivo de plantas forrajeras. [On the growing of forage plants.] *Agros, Montevideo.* II. (2). 181-3. (5, 6). 1910.

GASSNER, G. Ueber Keimungsbedingungen einiger südamerikanischer Gramineensamen. [On germination in some South American grass seeds.] *Ber. dtsch. bot. Ges.* 28. 350-64 and 504-12. 1910.

VENNE, H. van de. Bromatología. [Science of nutrition.] Montevideo. 1910.

———————— La alimentación racional de los animales domésticos. [The rational feeding of domestic animals.] *Agros, Montevideo.* II. 2 (1-6 incl.). 1910.

———————— El engorde a campo. [Fattening in the open grasslands.] (The first edition, out of print, was reprinted in 1935. *Agros, Montevideo.* 6 (127). pp. 20.)

1911

ARECHAVALETA, J., and HERTER. Vegetación uruguaya. Varias especies nuevas. [The vegetation of Uruguay. Various new species.] *An. Mus. Hist. nat. Montevideo.* Ser. II. 1 (3). 59-93. 1911.

DAMMANN, H., and SCHROEDER, J. Efectos tóxicos del sorgo. [Toxic effects of sorghum.] *Agros, Montevideo.* II. 2 (10). 283-90. 1911.

GASSNER, G. Keimuntersuchungen mit *Chloris ciliata.* [Studies of germination in *Chloris ciliata.*] *Ber. dtsch. bot. Ges.* 29. 708-22. 1911.

RIMBACH, A. Las enfermedades criptogámicas de la alfalfa. [The crytogamic diseases of lucerne.] *Agros, Montevideo.* II. 2 (12). 348-51. 1911.

SCHROEDER, J., and DAMMANN, H. Los efectos tóxicos de tres variedades de *Andropogon.* [The toxic effects of three varieties of *Andropogon.*] *Rev. Secc. Agron. Univ. Montevideo.* 8. 123-37. 1911.

1912

ESCUDERO CAPRARIO, W. Los prados artificiales de avena en la alimentación del ganado. [Artificial oat leys in the feeding of stock.] *Agros, Montevideo.* II. (2). 62-7. 1912.

GASSNER, G. Untersuchungen über die Wirksamkeit des Lichtes und des Temperaturwechsels auf die Keimung von *Chloris ciliata.* [Investigations on the action of light and of change of temperature on germination in *Chloris ciliata.*] *Jb. Hamburg wiss. Anst.* 1912. pp. 121. [Dissertation.]

1913

DE L'HARPE, J. Estudio histórico de la bromatología. [Historical study of the science of nutrition.] *Rev. Inst. Nac. Agron., Montevideo.* (11). 33-46. 1913.

———————— La vaca lechera, higiene y alimentación. [The dairy cow, hygiene and feeding.] *Rev. Min. Industr., Montevideo.* 6. 120-7. 7. 7-10. 1913.

———————— Consideraciones sobre el "valor almidón de Kellner." [Considerations on Kellner's starch equivalent.] *Agros, Montevideo.* II. 1 (8). 1913.

1913—(continued)

DEMOLIN, M. Industria lechera. Consideraciones económicas. [The dairy industry. Economic considerations.] *Rev. Min. Industr., Montevideo.* 1 (3). 105-15. 1913.

GASSNER, G. Uruguay I and II. Eleventh series. Parts 1-4 of the "Vegetationsbilder" [Vegetation pictures] published by Karsten and Schenck, Jena: G. Fischer. (Contains, in addition to general information on the vegetation of Uruguay, a description of the "steppe or pampas", noting the agrostological composition of the principal natural pastures.)

GUARINO FIECHTER, A. La alimentación de cerdos en crecimiento. [The feeding of growing pigs.] *Agros, Montevideo.* II. 1 (38-41). 1913.

MARI, J. A. Praderas. [Meadows.] *Agros, Montevideo.* 11 (5). 177-80. 1913.

PUIG Y NATTINO, J. Estudios sobre pastos naturales. [Studies of natural pastures.] *Rev. Min. Industr. Montevideo.* (3). 82-97. 1913.

RIMBACH, A. Tipos de vegetación de los campos uruguayos. [Types of vegetation in the Uruguayan grasslands.] *Rev. Inst. Agron. Montevideo.* (11). 11-26. 1913.

SCHROEDER, J. Ensayo de cultivo de maíz "amargo". [Trial of "bitter" maize.] *Rev. Inst. Agron. Montevideo.* (12). 41-5. 1913.

———— Investigaciones analítico-económicas y ensayos prácticos de cultivos de *Medicago sativa* en el Uruguay. [Analytical and economical studies and practical trials of *Medicago sativa* in Uruguay.] *Rev. Secc. Agron. Univ. Montevideo.* (12). 47-67. 1913.

1914

BERRO, M. B. La agricultura colonial. [The colonial agriculture.] Montevideo. 1914. pp. 351. (Contains isolated data on some forage plants of the colonial period.)

CASTRO CARAVIA, J. F. Escasez de proteína en el Uruguay. [Scarcity of protein in Uruguay.] 1914. (Dissertation.)

HELGUERA, H., Jr. Address presented to the National Livestock Congress held in the city of Minas, August 8-12, 1914. (Proposes the awarding of prizes to encourage research on forage problems.)

MESSNER, E. La toxicidad del revienta caballo (*Solanum pseudo-capsicum* L.). [The toxicity of *Solanum pseudo-capsicum* L.]. *Rev. Min. Industr. Montevideo.* 2 (11). 20-2. 1914.

PUIG Y NATTINO, J. Avenas. Deducciones saccadas del análisis químico-agrícola. (Cosecha 1913/14.) [Oats. Deductions obtained from chemical analysis. (1913/14 harvest.)] *Min. Industr. Bol.* No. 14. 25-9. Montevideo. 1914.

SCHROEDER, J. El valor forrajero de algunos desperdicios industriales recogidos en las repúblicas rioplatenses. [The forage value of some industrial refuse collected in the River Plate Republics.] *Rev. Asoc. Rur. Uruguay.* (43). 1914.

1915

PAPAIOANNOU, J. H. Experiencias sobre plantas forrajeras. [Experiments with forage plants.] *Rev. Min. Industr. Montevideo.* (14). 15-31. 1915.

PUIG Y NATTINO, J. Ensayos de cultivo de remolacha forrajera. [Fodder beet trials.] *Rev. Min. Industr. Montevideo.* (17). 65-74. 1915.

SCHROEDER, J. El valor alimenticio y la composición químico-agrícola de algunos productos secondarios de las industrias nacionales. [The nutritive value and the chemical composition of some by-products of the national industries.] *Rev. Min. Industr. Montevideo.* 2. (12). 10-32. 1915.

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———— Contribución al conocimiento químico-agrícola de las "tunas" en las repúblicas rioplatenses. [The chemical composition of the *Opuntia* spp. of the River Plate Republics.] *Rev. Min. Industr. Montevideo.* 3 (13). 15-25. 1915.

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BARCIA TRELLES, J. Selección de simientes. La alfalfa de Totana. [Seed selection. The Totana lucerne.] *Rev. Min. Industr. Montevideo.* 4 (22). 41-4. 1916.

MONTORO GUARCH, A. Notas sobre el cultivo de la alfalfa. [Notes on the cultivation of lucerne.] *Rev. Asoc. Rur. Uruguay.* 45 (12). 649-63. 1916.

MOREIRA ACOSTA, S., and MENDIZABAL, M. P. Contribución al estudio del problema forrajero. [Contribution to the study of the forage problem.] *Bol. Insp. Nac. Ganad. Agric. Montevideo.* (18). 3-22. 1916.

RIMBACH, A. Observaciones sobre plantas forrajeras. [Observations on forage plants.] *Rev. Min. Industr. Montevideo.* (27). 13-6. 1916.

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1917

BOERGER, A. Experiencias realizadas con avenales y alfalfares para forrajes. [Trials of oat and lucerne leys for forage.] *Rev. Min. Industr. Montevideo.* 5 (30). 260-8. 1917.

SOTO, J. de. Anotaciones sobre ensilaje. [Notes on ensilage.] *Agros, Montevideo.* III. 1 (1). 35-7. 1917.

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MURGUIA, L. J. Contribución al estudio de la osteomalacia en el Uruguay. [Contribution to the study of osteomalacia in Uruguay.] Insp. Nac. de Policía San. Animal. *Rev. Min. Industr. Montevideo.* 5 (32). 460-86. 1917.

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REVISTA ASOCIACION RURAL DEL URUGUAY. El engorde de los animales vacunos. [The fattening of cattle.] *Agros, Montevideo.* III. 1 (7/8). 36-8. 1917.

RUBINO, M. C. Informe acerca de una nueva enfermedad en los bovinos, observada en varios establecimientos del Departamento de Durazno. [Report on a new disease of cattle observed on various ranches of the Department of Durazno.] *Rev. Min. Industr. Montevideo.* 5 (31). 430-2. 1917. (Osteomalacia.)

XIMENEZ, R. Muñoz. Casos de osteomalacia o caquexia ósea. [Cases of osteomalacia or bone cachexia.] Insp. Nac. de Policía San. Animal. *Rev. Min. Industr. Montevideo.* 5 (31). 428-30. 1917.

1918

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MESSNER, E. Contribución a la toxicología del *Cestrum parqui* l'Herit. (vulg. duraznillo negro.) [The toxicology of *Cestrum parqui* l'Herit.] *Rev. Min. Industr. Montevideo.* 6 (41.) 537-55. 1918.

———————. La acción irritante de la *Baccharis coridifolia* D.C., vulg. miomio. [The irritant action of *Baccharis coridifolia* D.C.] *Rev. Min. Industr. Montevideo.* 6(41). 556-72. 1918.

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1918—(continued)

MULLIN, J. Tabla de composición y la digestibilidad de los alimentos destinados a los animales domésticos. [Table of the composition and digestibility of feeding stuffs.] *Agros, Montevideo.* III. 2(13, 14, 15). 6-39. 1918.

SANCHEZ ROGE, H. Alimentación y selección. [Feeding and selection.] *Agros, Montevideo.* III. 2(16, 17). 140-7. 1918.

———————— El estudio de la vegetación en los campos dedicados a la ganadería. [The study of the vegetation of the campos devoted to stock-raising.] *Agros, Montevideo.* 1(9/10). 46-53. 1918.

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SALGUEIRO SILVEIRA, R. Empleo de la cáscara de maní, de las hojas y del maní en grano como forraje. [Use of the shell of the groundnut, of the leaves and of the groundnut itself as forage.] *Agros, Montevideo.* III. 2(16, 17). 131-6. 1918. 2(18, 19, 20). 171-4. 1919.

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DUTTO, M. *Phalaris bulbosa.* Conveniencia de su cultivo para la formación de praderas permanentes. [*Phalaris bulbosa.* Its suitability for permanent meadows.] *Rev. Asoc. Rur. Uruguay.* No. 7. 1919.

FLEURQUIN, J. Yates. Informe sobre un campo alfalfado de pastoreo. [Report on a pasture containing lucerne.] *Rev. Min. Industr. Montevideo.* 7(47). 339-41. 1919.

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RODRIGUEZ SOCRATES, S. La parva-silo. Insp. Nac. Ganad. Agric. No. 35. Montevideo. 1919. pp. 22.

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SOTO, J. de. Temas de animalicultura. Las praderas. [Stock-raising questions. The meadows.] *Agros, Montevideo.* III. 3 (32, 33). 235-44. 1920.

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PUIG Y NATTINO, J. El sorgo azucarado. Estudio de las diversas variedades, su importancia como alimento para el ganado. [Sweet sorghum. Study of the different varieties, and their importance as feed for cattle.] *Bol.* No. 39. *Min. Industr. Inspecc. Nac. Ganad. Agric. Montevideo.* 1920.

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1922

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REVIEWS

FORAGE ROOT CROPS

[Reviewer : R. O. Whyte]

The publication of a Farmers' Bulletin (No. 88) by the Canadian Department of Agriculture on " Field roots in Canada ; classification, improvement and seed production ", a contribution from the Division of Forage Plants (Ottawa, Feb. 1940 ; a revision of Bull. 84) provides an opportunity to note the progress made by this Bureau in the preparation of an international bulletin on the use of root crops as animal fodder.

Although in the early days of the Herbage Bureau, little reference was made in *Herbage Abstracts* to literature on the use of root crops as fodder, in the later years abstracts began to be included in that journal. These abstracts led L. C. Raymond, Assistant Professor of Agronomy at Macdonald College, to suggest in a letter dated November 4, 1938, that it might be advisable for this Bureau to publish something in Bulletin form dealing with the forage root question in all important countries of the world. " This is a subject on which there is a tremendous dearth of accessible information, chiefly due to the fact that most of the publications appear in non-popular languages."

Among the aspects Professor Raymond considered might be covered were production and geographical distribution, soil and climatic adaptations, methods of cultivation, storage, breeding and varieties.

Although the Bureau staff was at the time engaged on the preparation of some large Bulletins, most of which have now been published, a circular letter was sent to all Official Correspondents, Corresponding Editors and Liaison Officers, asking for their comments as to the advisability of producing such a Bulletin. It was suggested that possibly the most valuable information might be obtained from the agronomists of Russia, Scandinavia, Germany, France and Great Britain, with possibly New Zealand and other countries in the Southern Hemisphere. It was hoped that the Bulletin might be of the nature of a symposium, on the lines of Bulletins 27, 28, 29 and Joint Publication No. 3, containing articles by selected specialists in the various countries.

A number of replies were received to the circulated correspondence, extracts from which are given below, but with the gradual deterioration of conditions in Europe up to the outbreak of hostilities on Sept. 3, it became obvious that it would be increasingly difficult to maintain contact with correspondents and collect the desired articles. The forage root bulletin was therefore not one of those to the completion of which the Bureau staff devoted their energies during the winter of 1939-40. During the present abnormal situation, it is unlikely that the Bureau will be publishing many Bulletins, but if occasion permits attention will be given to the preparation of a contribution on forage roots. In the meantime, it may be of interest to give extracts from the correspondence, and to refer briefly to the Canadian Bulletin on the subject.

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Sir Frank Stockdale*, Agricultural Adviser to the Secretary of State for the Colonies, Colonial Advisory Council of Agriculture and Animal Health, Colonial

*See page 240.

Office, London, considered (Jan. 7, 1939) that, while the proposed work would be of greater value to agriculture in temperate climates, it would nevertheless be worth doing, and a small section should be included on tropical aspects.

As far as the tropics are concerned, the most important root crops being used as forage are cassava and sweet potato. Cassava tubers are largely used for cattle forage in Mauritius and their use has recently been started by the Veterinary Department at Pong Tamale, Gold Coast. Certain precautions have to be taken in the feeding of fresh cassava roots. The waste material from tapioca (made from cassava) factories is used in Malaya and pig keeping there by the Chinese would not be profitable but for this waste material from tapioca factories. Sweet potatoes and tops are fed to animals in very many parts of the tropics and it may be said that mixed farming in Nigeria depends upon the sweet potato vines for providing some green food in the height of the dry season.

Dr. F. T. Wahlen, Director of the Swiss Experimental Station for Agriculture, Zürich-Oerlikon, recommended (Jan. 19, 1939) that Professor Raymond's suggestion should be acted upon. He would himself be willing to give a brief statement upon the part played by forage roots in Swiss agriculture. It would be necessary to include to a certain extent, apart from forage roots proper, such crops as sugar beet and potatoes, which are now becoming increasingly used on the Continent. It was also suggested that the German collaborator should be invited to give a brief account of the very important part played by sugar beet, fed either as such or in the form of factory residues, and by potatoes, in the feeding of livestock in Germany.

Professor E. Klapp, Institut für Boden- u. Pflanzenbaulehre an der Universität Bonn, Katzenburgweg 5, considered (Jan. 13, 1939) that such a bulletin would be very desirable and offered to assist in selecting a German contributor who would provide an article dealing chiefly with the genera *Beta*, *Brassica* and *Daucus*, and with potatoes.

M. Caffrey, Albert Agricultural College, Glasnevin, Dublin, and his colleagues in the Faculty of Agriculture also supported the Bulletin (Jan. 19, 1939), and considered that root crops do not occupy a place in the literature commensurate with their importance in the agriculture of Great Britain and Eire. It was stated that M. J. Gorman, Lecturer in Agricultural Botany,would be in a position to assist in the work of compilation.

While supporting the idea of publishing the Bulletin, P. V. Cardon, the Principal Agronomist in Charge of the Division of Forage Crops and Diseases, Bureau of Plant Industry, U.S. Department of Agriculture, doubted whether the United States would be able to offer much of a contribution in this direction, as forage roots are used only to a very limited extent (Jan. 30, 1939).

The Chief and Assistant Chief of the Division of Plant Industry, South Africa, stated (Jan. 25, 1939) that information concerning the experience of other countries in respect of root crop production is badly needed ; for various reasons, root crop production is not common in South Africa, although these crops would be of great value in dairy and mixed farming. Root crop production in South Africa is erratic and therefore does not command the attention of the majority of farmers. The difficulty in growing is often associated with the rainfall and good " stands " are frequently difficult to obtain. Insect pests are also an important problem.

Information could be supplied from South Africa on substitutes for root crops, for example, pumpkins, kaffir melons, etc. It was suggested that the title of the proposed Bulletin might be amended to " Root and other succulent crops for forage purposes ".

Dr. W. Burns, Agricultural Commissioner with the Government of India, Imperial Council of Agricultural Research, New Delhi, did not consider that this was a matter

upon which India might collaborate, as forage roots are of importance only in certain limited parts of India (Feb. 6, 1939).

Concerning production in Italy, Dr. E. Pantanelli, Stazione Agraria Sperimentale, Bari, stated (Jan. 30, 1939) that only mangolds and rape are grown as fodder root crops, the former throughout the whole of northern and central Italy, the latter in Lombardy and the districts around Naples. Particular attention has been devoted to the mangold in North Italy, and it was considered that it would be of interest to learn what results have been obtained regarding varieties and also production and conservation.

Dr. B. T. Dickson, Chief of the Division of Plant Industry, Council for Scientific and Industrial Research, Canberra City, F.C.T. (Jan. 26, 1939), stated that forage roots constitute only a relatively small proportion of the stock requirements in Australia, although they are grown to some extent in Tasmania and Victoria. It might be possible to include a contribution from Australia.

Dr. T. M. Stevenson, Dominion Agrostologist, Division of Forage Plants, Central Experimental Farm, Ottawa (Feb. 6, 1939), stated that this question was discussed by correspondence with various Canadian specialists, the views of whom were quite varied. Most were of the opinion that the existing Canadian publications cover the subject fairly well as far as Canada is concerned, but that it would be helpful to have information regarding the extent to which roots are grown, cultural methods, and breeding methods in European countries and Great Britain. It would be possible to make some additions to the information already published in Canadian bulletins, such as the arrangements for the production of registered seed, trade in table stock, and breeding methods for disease resistance and seed production. (At least some of these aspects are now dealt with in the new Canadian bulletin mentioned at the beginning of this review.)

Dr. Stevenson also maintained that a considerable amount of information regarding cultural methods, breeding technique, etc., could be obtained from the United States, and would particularly welcome an account of the methods employed in the southern States for the production of sugar beet seed (Herbage Publication Series Bull. 26. pp. 88-9, under New Mexico). " Personally, I should like to see a bulletin on forage roots prepared in the next several years. I do not think, however, that the need for it is urgent, except for those who are engaged in teaching work where, we must admit, there is a scarcity of forage root information throughout the world."

Prof. Fr. Chmelař of the Seed Testing Station, Brno, Czechoslovakia, welcomed the proposal to publish a Bulletin on forage roots and promised a contribution from Czechoslovakia (May 21, 1939). Crops of special importance there are the turnip, fodder carrot, and in some parts kohlrabi.

* * * * *

This is the position to date regarding the project to produce a Bulletin on forage roots. It is obviously impossible now to publish anything approaching a completely representative international symposium on the subject. The question will be borne actively in mind in the Bureau, but it is doubtful whether the staff could produce a satisfactory Bulletin without European collaboration. Such literature as becomes available will be dealt with in the usual way in *Herbage Abstracts*. Any original articles or other information will be included in a special supplement of that journal, to be published as a temporary substitute for *Herbage Reviews*.

* * * * *

The new Canadian Bulletin (Farmers' Bull. 88) contains sections on the history, distribution, classification, yield, breeding and seed raising of the root crops of importance as animal fodder in that country, namely, mangels, swedes (rutabagas), turnips and carrots.

The use of these crops as a medium for increasing the succulence of animal rations has been quite common in the more humid districts since the pioneer days, but their cultivation has not become much more general principally because of the cost of raising such crops. Most growers still do their thinning and harvesting by hand. It is much more economical to handle field corn, sunflowers and annual hays with modern machinery. Again, there is much confusion in nomenclature, with the result that unadapted types are frequently planted.

One of the objects of this bulletin is to present a classification and description of field root varieties offered for sale in Canada, in order to assist farmers in the selection of suitable varieties.

Canadian-grown seed has compared favourably with the best imported seed in its ability to produce profitable crops. The growing of root seed is therefore recommended and the problem of producing seed of field roots is discussed in some detail.

In considering the factors affecting yield, reference is made almost entirely to the different factors in so far as their effect on the mangel crop is concerned. It is stated that the extreme variations in type which occur in the mangel render it particularly suitable for ecological studies.

A special section is devoted to breeding work, with reference to the production of suitable types, the study of mangel leaf types, isolation of field roots, and methods of isolation.

PASTURE MANAGEMENT AND SOIL CONSERVATION

[Reviewer: R. O. WHYTE]

It had been hoped that this issue of *Herb. Rev.* would contain an article by C. R. Enlow, Chief of the Agronomy Division of the U.S. Soil Conservation Service, on the developments in the use of pasture improvement in relation to erosion control in the United States since the article published in the Report of the Fourth International Grassland Congress, 1937, pp. 97-107. As this is not now possible, readers are referred instead to a special issue of *Soil Conservation* for April, 1940 which contains the following articles, and which may be said to provide information on the present outlook regarding the use of pastures in connexion with soil conservation in the various regions of the United States.

Soil, plant and livestock relationships. A. T. Semple.
Pasture in relation to cropland. W. V. Kell.
A grazing program for soil conservation in the Southeast. R. Y. Bailey.
Profitable pastures for the Ohio Valley. R. H. Morrish.
Grazing management for permanent pastures in Corn Belt and Northeastern States. M. A. Hein.
Better pastures for Illinois. E. D. Walker.
Factors in pasture management in the Northeast. G. F. Brown.
Run-off under different systems of grassland management. H. C. Knoblauch and J. L. Haynes.

It is recognized that people cannot live on grass alone, nor can a satisfactory agricultural system be based on any extensive area wholly upon a cash-crop system.

The production of both cultivated crops and grass or pasture is necessary, and the problem is to decide the balance which should be maintained between pasture and cultivated land.

Pasture is to be regarded as a farm crop and will produce good or poor returns in proportion to the attention it receives. Grass is largely responsible for making the crop land productive, and the farmer who permits his land to rest at intervals in grass can maintain soil fertility more easily and effectively than the farmer who attempts continuous production of cash crops.

Results are quoted to show how effectively a good grass sward encourages infiltration rather than run-off, and holds the soil against the erosive factors of water and wind. The fibrous root systems of grasses are of great importance in providing a stable form of organic matter, as they break down by oxidation less rapidly than organic matter or vegetation on the surface of the soil. Soil filled with this type of organic matter not only will resist erosion and absorb and hold more water, but will possess a " good soil structure ".

With only part of the farm now in cash crops and some of it in pasture, which for best utilization requires the keeping of livestock, many of the risks associated with periods of economic depression are removed.

Pasture is very closely associated with diversified farming. Feed can be produced less expensively from pasture than in any other form ; for example, in one study on market milk production it was shown that pastures furnished nearly one-third the feed at only one-seventh the total feed cost.

Like any other crop, pasture must be adapted to its environment and to the needs of the farm. The proportion of pasture to crops is to be determined by two factors ; first, the amount of time the land should be in grass to ensure soil stability and productiveness, and second, the amount of pasture required to provide a balance with cultivated feed crops so that livestock can be profitably maintained throughout the year.

In areas of limited rainfall, such as the Great Plains, the proportion of pasture to crop land should be much larger than in humid areas, and should vary from one-fourth pasture and three-fourth crops, to one-fourth crops and three-fourths pasture. In areas where one-half to three-fourths of the land should be in grass, the cropping unit probably should be from 160 to 240 acres with 600 to 1,000 acres of pasture land. In an extensive system of farming a unit of this size should provide a living for one family.

Although certain factors, such as mild winters, high annual rainfall and a long growing season favour pasture development in the south-east, there are also serious disadvantages, particularly poor soils and uneven seasonal distribution of rainfall. The eroded soils have a low water-holding capacity, with the result that pasture plants suffer from drought. With the exception of lowland areas along streams and in natural depressions, most of the land available is too dry for good pasture.

Much of the hilly land in the south-east will, however, grow annual lespedeza, particularly if the soils are moderately heavy and phosphates are applied. On the sandy soils of the Coastal Plains, annual lespedeza suffers from drought and is less dependable than such deep-rooted perennials as the kudzu vine (*Pueraria thunbergiana*) and *Lespedeza sericea*.

A simple grazing programme recommended for these conditions in the south-east includes (1) permanent pasture on the lowland areas, (2) sufficient *Lespedeza sericea* for spring grazing, (3) pure stands of annual lespedeza on suitable upland, and (4) sufficient kudzu for grazing during the autumn when grass and annual lespedeza are retarded by drought.

On too many farms in the Ohio Valley is pasture actually mere "ground", bare or infested with weeds and unpalatable grasses, from which the topsoil has been lost by erosion. A considerable number of farmers have successfully established and maintained profitable pastures by the timely use of good cultural practices and sensible management. Neglected fields are beginning to receive much needed attention and are responding satisfactorily. Difficulties which hinder this improvement include worn-out soils (not general), overstocking on most farms, inadequate fencing, and the practice of winter grazing.

To ensure sufficient pasture during the critical summer months in the Corn Belt and north-eastern States, one of several methods of grazing management may be adopted. Grazing may be deferred or rotational, the excess spring growth may be removed for hay or silage, and supplemental pasture and fodder crops may be grown for the summer period. The practice of using the hay aftermath for supplemental pasture is one that should be more widely employed in the region.

The Extension Service in Illinois is stressing the fact that a pasture can be no better than the soil upon which it grows. As a result, there is a markedly increased acreage of really good mixed grass-legume pasture on land retired from crop production under the adjustment programme. Meetings and demonstrations are playing an important part in the drive for better pasture management in the State.

There are in the north-eastern States about 25,000,000 acres of pasture, one-third of which may be classed as woodland pasture. The grazing season varies from five to seven months. Many farms allow their livestock to roam the pastures during most of the year—a very injurious practice.

From the point of view of pasture management there are at least three periods in the grazing season when care is necessary, namely, in early spring while the ground is still soft, in the hottest part of the summer, and in the autumn, when overgrazing will cause the herbage species to enter the winter in a weakened condition.

In the north-eastern region, proper liming, fertilizing, seeding, mowing and grazing management are all very important, but adequate moisture must also be added as one of the fundamental requirements. Contour furrowing is one of the practices recommended by the Soil Conservation Service to help to counteract the moisture shortage during the summer months. As properly constructed in the region, contour furrows on pastures have a holding capacity of about one acre-inch, equivalent to about 113 tons of water per acre. About 6,000 acres of permanent pastures have been furrowed in the north-eastern region in recent years.

Although it is generally recognized that land used for grass production does not generally present as serious an erosion problem as does that devoted to cultivated crops, the differences in run-off from various types of grass under different systems of management are less widely appreciated.

The Beemerville Soil Conservation Experiment Station was established near Sussex, New Jersey, to determine soil and water losses under various agricultural practices related to dairy farming, for example, from pasture land when rotationally grazed and when under continuous grazing, from areas planted to grass-legume mixtures cut for ensilage, and from corn plots harvested for ensilage. Preliminary results of some studies in progress since 1937 are now becoming available, and the following table gives an idea of the type of data being collected.

Table showing run-off from grassland under different systems of management as compared with that from corn planted with the slope.

Season	Rainfall	Run-off from corn (silage)	Run-off from grass-legume (silage)	Run-off from bluegrass-clover sod, continuous grazing	Run-off from bluegrass-clover sod, rotational grazing
	Inches	Per cent	Per cent	Per cent	Per cent
June, July, Aug.	14.59	8.2	3.4	8.8	5.7
Sept., Oct., Nov. ..	11.64	7.3	2.2	8.2	4.8
Dec., Jan., Feb.	11.54	40.6	9.1	44.2	25.4
Mar., Apr., May	11.31	1.0	0.2	1.0	0.3
Total, 12 months ..	49.08	14.0	3.7	15.2	8.9
Annual soil loss (tons per acre).....		10.88	0.05	0.22	0.17

It is apparent that under these conditions soil losses under any reasonably good system of grassland management are small, except from new seedings. The comparatively recent trend from the use of corn silage to grass-legume silage in the region is welcomed as being a big step forward in one of the major conservation problems in dairy farming.

INTERCEPTION OF RAINFALL BY PRAIRIE PLANTS

[Reviewer: R. O. WHYTE]

Although much attention has been given to the loss of water through run-off, evaporation from the soil and by transpiration, the water loss sustained through interception by herbaceous vegetation has received very little consideration. The latest contribution from Dr. J. E. Weaver's department at the University of Nebraska is concerned with this particular aspect, O. R. Clark having made a study of the amount of interception characteristic of prairie grasses, prairie forbs and weeds, planted crops, mat-forming weeds and densely aggregrated grasses (*Ecological Monographs*, 10. No. 2. 243-77. 1940).

The author first reviews the literature on related topics such as comparisons of rainfall in evergreen and deciduous forests with precipitation in the open, the measurement of interception by trees, crops and other herbaceous vegetation, penetration of rainfall in pine forest and hardwood forest, the importance of the interception of rainfall by vegetation in the control of surface run-off and erosion, and similar subjects.

Preliminary work on the present study was done in 1936 and extensive experiments followed during the growing seasons of 1937 and 1938. All the plant materials were secured within a radius of twenty miles of Lincoln, Nebraska.

As the season of 1937 was one of severe drought, it became necessary to develop a method by which water could be sprinkled upon the plants in a manner resembling natural rainfall (Clark, *Science*, 86. 591-2. 1937; *Herb. Abstr.* 8. Abs. 325. 1938). Two methods were developed and used in the collection of data, one in the field trials, the other in experiments in the greenhouse and laboratory.

Table 1.—Percentage interception by a square metre of Andropogon furcatus Muhl. of lowland prairie

Date	Application		Sky	Wind	Temp. Deg. F.	Humidity per cent	Evap. cc.	Per cent
	Inches	Minutes						
1937								
June 23	0.25	30	Clear	Strong	101	27	—	81[1]
,,	0.5	,,	,,	,,	102	26	2.3	66[1]
June 25	0.125	,,	Partly cloudy	,,	88	64	0.8	65[1]
,,	0.25	,,	Cloudy	,,	82	76	0.8	57[1]
June 28	0.25	,,	,,	Moderate	76	70	0.3	61[1]
,,	0.25	,,	,,	,,	75	66	0.4	69[2]
June 29	0.25	,,	Clear	,,	79	47	1.6	69[1]
,,	0.25	,,	,,	,,	78	43	1.6	69[2]
June 30	0.125	,,	Partly cloudy	Light	89	35	1.2	67[1]
,,	0.125	,,	,,	,,	94	27	1.2	72
July 2	0.5	,,	Clear	,,	89	38	0.8	57[1]
,,	0.5	,,	,,	,,	92	29	1.2	61
Aug. 18	1.0	60	Partly cloudy	Moderate	88	61	2.3	47[1]
,,	0.5	30	,, ,,	,,	94	46	1.6	58[1]
,,	0.25	,,	,, ,,	,,	94	44	2.3	68[1]
Aug. 25	0.125	,,	,, ,,	Light	86	57	1.6	81[1]
,,	0.125	,,	,, ,,	,,	92	48	1.6	84[2]
1938								
July 20	2.0	60	Partly cloudy	Moderate	81	41	—	51[1]

[1]Plants cut where necessary and placed in pans.
[2]Plants cut but placed outside pans.

Table 2.—Percentage interception by a square metre of Andropogon furcatus Muhl. of upland prairie

Date	Application		Sky	Wind	Temp. Deg. F.	Humidity per cent	Evap. cc.	Per cent
	Inches	Minutes						
July 23	0.5	30	Clear	Strong	97	26	2.3	50
,, 30	,,	,,	Partly cloudy	Moderate	85	67	0.8	56
,, ,,	,,	,,	,, ,,	Light	88	61	1.6	63
,, ,,	,,	,,	Mostly clear	,,	89	59	1.6	51

Table 3.—Percentage interception by a square metre of Andropogon furcatus Muhl. with other grasses and forbs

Date	Application		Sky	Wind	Temp. Deg. F.	Humidity per cent	Evap. cc.	Per cent
	Inches	Minutes						
July 22	0.25	30	Clear	Strong	97	33	2.3	54
,, 23	0.25	,,	,,	,,	97	26	4.0	56
,, 29	0.25	,,	Partly cloudy	Moderate	90	47	1.6	51
,, ,,	1.0	60	,, ,,	,,	92	45	3.1	43
,, ,,	0.125	30	,, ,,	,,	88	49	0.8	57

Table 4.—Percentage interception by a square metre of various grasses.

Date	Application		Sky	Wind	Temp. Deg. F.	Humidity per cent	Evap. cc.	Per cent
	Inches	Minutes						
			Stipa spartea Trin.					
July 15	0.25	30	Mostly clear	Light	91	51	1.6	49[1]
,,	0.25	,,	,, ,,	,,	94	44	1.6	50[2]
,,	0.125	,,	,, ,,	,,	94	39	2.3	59[1]
			Sporobolus heterolepis A. Gray					
July 22	0.25	30	Clear	Strong	97	28	3.1	54[1]
,,	0.25	,,	,,	,,	97	30	3.9	60[2]
July 28	0.125	,,	Mostly clear	Moderate	88	46	1.6	53[1]
,,	0.25	,,	Clear	,,	94	34	3.1	50[1]
,,	1.0	60	,,	,,	94	32	5.5	29[1]
			Agropyron smithii Rydb.					
July 13	0.25	30	Cloudy	Strong	86	63	1.2	46[1]
,,	0.25	,,	,,	,,	88	61	1.6	50[2]
			Elymus canadensis L.					
July 14	0.25	30	Partly cloudy	Moderate	89	55	0.8	62[1]
,,	0.25	,,	,, ,,	,,	85	65	0.8	61[2]

[1]Plants cut where necessary and placed in interceptometer pans.
[2]Plants cut but not placed in pans.

Table 5.—Percentage interception by a square metre of Spartina pectinata Link.

Date	Application		Sky	Wind	Temp. Deg. F.	Humidity per cent	Evap. cc.	Per cent
	Inches	Minutes						
1937								
July 8	0.5	30	Partly cloudy	Moderate	85	50	1.6	53[1]
,,	0.5	,,	,, ,,	,,	87	39	1.6	58
,,	0.25	,,	,, ,,	,,	90	39	2.3	69
,,	0.25	,,	,, ,,	,,	90	42	2.3	68[1]
July 9	0.125	,,	,, ,,	,,	93	40	2.3	70[1]
,,	0.125	,,	,, ,,	,,	94	34	2.4	75
July 21	0.25	,,	,, ,,	Light	91	44	1.6	73[1]
,,	0.25	,,	,, ,,	,,	92	38	1.6	81[2]
1938								
Aug. 6	2.0	60	Clear	Strong	83	57	4.0	74

[1]Plants cut where necessary and placed in pans.
[2]Plants cut but placed outside pans.

Table 10.—Percentage interception by densely aggregated grasses.

Date	Application		Sky	Wind	Temp. Deg. F.	Humidity per cent	Evap. cc.	Per cent
	Inches	Minutes						
				Eragrostis cilianensis (All.) Link.				
Aug. 10	1.0	60	1 sq. yd.	12 m.p.h.	89	42	6	18
,,	0.5	30	,,	,,	89	47	3	22
,,	0.5	,,	,,	None	89	47	0.8	16
,,	0.25	,,	,,	12 m.p.h.	90	47	3	40
,,	0.125	,,	,,	,,	90	50	3	62
				Buchloë dactyloides (Nutt.) Engelm.				
Aug. 11	0.125	30	18×24 in.	12 m.p.h.	90	47	4	74
,,	0.25	,,	,,	,,	90	47	3	47
,,	0.5	,,	,,	None	88	49	0.8	17
,,	0.5	,,	,,	12 m.p.h.	87	43	3	31
Aug. 12	1.0	60	,,	,,	84	38	7	26

Table 11.—Maximum interception capacity of a square foot of plant materials in grams.

Living plants

Melilotus alba Desv.	169	*Chamaesyce maculata* (L.) Small	52
Andropogon furcatus Muhl	217	*Polygonum aviculare* L	71
Spartina pectinata Link	77	*Eragrostis cilianensis* (All.) Link	229
Buchloë dactyloides (Nutt.) Engelm.	153	*Solidago altissima* L	214
Panicum	148	*Artemisia gnaphalodes* Nutt	261
Psoralea, Andropogon furcatus and *Poa pratensis*	221	*Convolvulus arvensis* L	137
Sporobolus heterolepis A. Gray	138	*Kochia scoparia* (L.) Schrad	148
Tribulus terrestris L.	74	*Setaria viridis* (L). Beauv.	137
Amarantus blitoides S. Wats.	47	*Atriplex argentea* Nutt	182
		Portulaca oleracea L	107

Dead plant materials

Hordeum pusillum Nutt	156	Wheat straw mulch	445
Bromus tectorum L	216	**Salsola pestifer* A. Nels	585

*Single living plant.

Numerous experiments were performed with prairie grasses of lowland areas, for example, big bluestem (*Andropogon furcatus*), a typical sod-former, a mixed association of big bluestem with *Stipa spartea*, *Bouteloua curtipendula* and *Sporobolus heterolepis*, a pure stand of *Agropyron smithii*, which has greatly increased its area in the middle west during the drought years, a pure stand of *Elymus canadensis*, and typical lowland sites with *Spartina pectinata*.

Two densely aggregated grasses were also studied. *Eragrostis cilianensis*, when growing in compact clumps, forms a very effective interception screen by holding water in numerous drops on the leaves, along the stems and in the flowering panicles. The dense foliage retained the water for a longer time than most of the other plants in these experiments.

The other dense grass was buffalo grass (*Buchloë dactyloides*), a low-growing native grass rarely attaining a height of more than 6 ins., but forming a dense stand, a species which has greatly increased its area during the great drought. The results

obtained with this species show strikingly the effect of rainfall intensity and wind movement upon percentage of interception, and help to explain why a good growth of buffalo grass is so efficient in retarding run-off and how ineffective are light showers in replenishing the moisture supply of the soil.

Observations were also made upon certain prairie forbs and weeds which frequently occur in pure societies suitable for records of interception capacity to be made. The species were *Helianthus grosse-serratus, Persicaria muhlenbergii, Solidago altissima, Aster salicifolius, A. multiflorus, Solidago glaberrima, Rhus glabra, Helianthus annuus, Amarantus retroflexus, Atriplex argentea* and *Kochia scoparia.*

Interception of rainfall by a square yard or a square foot of mat-forming weeds was determined in the laboratory on the following species: *Tribulus terrestris, Convolvulus arvensis, Portulaca oleracea, Amarantus blitoides* and *Polygonum aviculare.*

The amount of water intercepted by winter wheat, oats, and sweet clover were also ascertained.

Tables 1, 2, 3, 4, 5 and 10 from the original article are reproduced here to indicate the type of data collected. Tables 6, 7, 8 and 9 (not reproduced) supply similar data for forbs, weeds and crop plants.

* * * * *

Sixty-two experiments were performed with twenty-three different kinds of living or dead plant materials to determine the maximum load of water which they were capable of holding at one time. The data obtained are given in Table 11.

Interception under natural rainfall was observed by installing sets of five interceptometers in two prairies and three fields of cultivated crops. Results for wheat, oats, alfalfa, *Spartina pectinata* and *Andropogon furcatus* are given in Tables 12 to 16 (not reproduced).

Discussion

"It is apparent from the results of these experiments that a large percentage of the rain which falls upon an area covered with vegetation is held on the leaves and stems of the plants. The amount held depends upon a number of factors, among which the kind and density of vegetation are very important. Low-growing or mat-forming plants do not intercept as much rain as plants of greater height because of the smaller surface exposed. A dense cover of prairie vegetation forms a very effective series of screens upon which some of the water may be caught and prevented from reaching the ground. There are at least three such layers in true prairie. The uppermost one consists of the taller grasses and accompanying forbs. The forbs may be of the same or even greater height than the grasses. Below these is a layer of shorter grasses and forbs, while on or near the soil surface there occur many different rosette or mat plants and a few interstitial grasses which complete the vegetative cover. A single stalk of big bluestem with four to seven large leaves presents just that many levels upon which water may be held. The high capacity of prairie vegetation to withhold water is due to the many levels at which interception occurs and the large leaf surface to which water adheres."

Earlier workers have studied the total leaf surface exposed by various prairie plants. In the present study, similar measurements were made of the leaf surface exposed by typical square-foot areas of big bluestem and *Spartina pectinata.* Counting both sides of the leaves, the figures were 12.5 and 9 sq. ft. respectively.

Horton (*Monthly Weather Rev.* 47. 603-23. 1919) concluded that the loss from interception by fully grown crops may approach for a time that caused by trees, although the total annual loss would not be so great. Intertilled crops intercept less rainfall than crops such as alfalfa and clover.

The amount of water intercepted and thus not available to the plants depends upon the character of the rainfall as well as upon the kind and density of the vegetation. During light showers or mists, all but a very small percentage of the moisture may be held upon the plants and is evaporated later. Although the percentage of interception may be high during showers of low intensity, the amount of water held on the plants may not satisfy their storage capacity. During normal rainfall of long duration, a larger percentage of the moisture will reach the ground. Interception is high during light showers and mists or when much evaporation occurs during a rain. In showers of high intensity but of short duration, the storage capacity of the plants is soon reached and the percentage of interception is less than for showers of low intensity.

" The percentage of interception loss is also influenced by environmental conditions during the period of precipitation. In nature, it is the aggregate or collective effects of the factors which are important rather than their individual effects. All of the factors exert their influence upon interception through their effect upon evaporation. Normally the sky is overcast during periods of precipitation, but bright sunshine between showers increases evaporation and, indirectly, interception. Air temperature and relative humidity operating together influence the rate at which the plants dry after being wetted. It is possible for evaporation to occur during a shower since the air is often below the saturation point while rain is falling. Wind movement has a marked influence upon interception through its effect upon evaporation."

Many observations were made during these experiments or after showers, concerning the manner in which the water was held on the plants and the ease or difficulty with which the surfaces became wetted. In some it was retained as a surface film, or as drops along the margins or tips of leaves, or in large amounts in flowers of bindweed and in the axils of the spine-like leaves of Russian thistle.

In most of the grasses studied, including the cultivated ones, water was held principally as drops which often adhered to both surfaces. Drops were commonly formed also on the stems and were especially numerous on the inflorescences. There was a marked difference in the rate at which plants dried after being wetted. The possible absorption of some water held on the leaves and the effect of the character of the plant surface on interception were not determined. Consideration has been given in this and earlier works to the amount of water which reaches the ground by running down the stems ; the amount was significant in corn and soybeans, but slight in alfalfa, oats and timothy. Clark concludes that the amount reaching the soil in this way is small compared with that dripping directly from the leaves.

" When the amount of water prevented from reaching the soil is expressed in tons per acre, the magnitude of interception by herbaceous vegetation may be more readily appreciated." The following figures are given as the total weight of water in tons per acre that some common plants are capable of holding at one time : bindweed, 6.5 ; buffalo grass, 7 ; sweet clover, 8 ; big bluestem, 10 ; *Eragrostis cilianensis*, 11 ; *Artemisia gnaphalodes*, 12.5.

When the calculations are based upon the percentage of interception during the application of known amounts of water in given periods of time, the amounts held per acre of vegetation are still larger, varying (with half an inch of water applied in 30 mins.) from a 13 per cent interception and load of 7.5 tons per acre for bindweed, to 61 per cent and 34 tons for big bluestem. With a rainfall increased to 2 inches per hour, the figures ranged from 43 per cent, 97 tons for oats, to 74 per cent, 167 tons for *Spartina pectinata*. The results for *Spartina* were unusually high because of the density of the stand and conditions favourable to evaporation.

Thus vegetation plays a variable role in determining how much of the water

precipitated will finally enter the soil and become available for absorption by the roots. Clark shows that a large amount may be intercepted by plants and prevented from reaching the soil. Some may be held only temporarily, eventually running down the stems to the ground. Some of the water which penetrates the plant cover may run off instead of being absorbed, although this is of course much less under prairie vegetation than with certain cultivated crops or fallow land.

" Native vegetation, especially grassland, is one of the decisive factors in the conservation of water through its effect upon run-off and percolation, as well as checking evaporation by shading the soil. On the other hand, vegetation has an important influence upon losses of water from the soil. That very large amounts are lost through interception has already been shown. Losses by transpiration from normal prairie averaged almost 32 tons per acre per day over a three-year period " (Flory, *Ecology*. 17. 67-103. 1936 ; *Herb. Abstr.* 6. 123. 1936).

" Kittredge (*J. Forestry*. 36. 775-8. 1938) has calculated for different major types of vegetation of the United States the annual water losses due to interception, transpiration, and evaporation. It is noteworthy that in short grass they are as great as those in ponderosa pine, and in tall-grass prairie they are as large as in oak-hickory forest. Additional losses may occur through evaporation where there is no vegetation or by seepage into rock strata but these are small as compared with those brought about by vegetation."

SOIL CONSERVATION IN PUERTO RICO

[Reviewer : R. O. Whyte]

The conservation of soil, water and vegetation under the conditions of climate, topography, cropping systems and soils of the West Indies and the countries around the Caribbean Sea is a very important and urgent problem. The development of conservation practices and the research items pertaining to those being studied by the Soil Conservation Service of the U.S. Department of Agriculture in the island of Puerto Rico must therefore create a wide interest and have a general application throughout the islands and countries in or bordering on the Caribbean. It is noted, for example, in the special issue of *Soil Conservation* upon which this review is based (July, 1940) that the programme has been extended to the other American possessions, the Virgin Islands, and that it has attracted attention in Jamaica, Haiti, Hawaii, Ecuador, Colombia and Venezuela.

In 1935, Soil Conservation Service employees made a reconnaissance erosion survey in Puerto Rico, and a soil conservation camp was set up through the co-operative efforts of the Puerto Rico Reconstruction Administration (P.R.R.A.), the Puerto Rican Experiment Station of the U.S. Department of Agriculture and the Forestry Service. The men in this camp were employed in constructing bench terraces with hand tools on land with an average slope of 35 per cent.

During a period of experimentation on the suitable type of bench terrace for conditions in the island, plans were prepared for an island-wide conservation programme ; the plans were made with the assistance of the Soil Conservation Advisory Committee, and it was decided that an agricultural engineer and a conservation agronomist should be placed in each soil conservation area. Two soils specialists were to be located at headquarters, to cover the whole island. Twenty local college

graduates trained in engineering, agronomy, and soils were also employed. This programme has been developed until there are now about sixty technical men and about 1,500 skilled, semi-skilled and unskilled labourers in the employ of the Soil Conservation Service. Each Soil Conservation Service technician is supervising from two to four areas.

Soil conservation experiment stations have been formed, one on Federal land at Mayaguez occupied by the Experiment Station of the U.S.D.A., and one at Rio Piedras, on insular land occupied by the Agricultural Experiment Station of the University of Puerto Rico, and in co-operation with the director.

Forty per cent or more of the arable land of the island has a slope of 40 per cent or greater; there are more than 500 people per square mile; about 80 per cent depend directly or indirectly upon agriculture for a livelihood. It is obvious that the successful control of erosion and conservation of moisture on steep mountain-sides are essential parts of a conservation programme; thus the first important problems to be undertaken at the Mayaguez Station included the control of bench terrace banks. After the proper slope and the type of grass best adapted for bank cover had been determined, an experiment was started, and is still in progress, to discover a food crop that could be grown on these banks in place of the grass cover. An attempt is being made, through the use of stiff upright-growing plants planted on the contour or a slight grade, to develop the vegetative barrier method of constructing bench terraces, as being cheaper than the hand construction method. Other problems being studied at Mayaguez and Rio Piedras include the relative values of different types of vegetation, the erodibility of fallow land and subsoil through the use of run-off measuring plots, the root systems, crown and growth characteristics, and the nutritive value of grass species, digestibility of grass species, and the erodibility of soils as related to their chemical and physical properties.

The operation programme must necessarily be concerned with the adjustment of bench width to type of soil, extent of erosion, degree of slope and, very important, depth to rock. The agronomist must establish vegetation in outlet channels for permanent use and service at minimum original outlay and upkeep, on slopes up to 70 per cent.

The above paragraphs are largely quotations from the opening article in this special issue of Soil Conservation, "Soil conservation program in Puerto Rico", by G. L. Crawford. The other articles in the same issue are:

The island of Puerto Rico, which has recently been included in Region 2 of the Soil Conservation Service (see *Herb. Publ. Ser. Bull.* 26. p. 44) is about 100 miles long by 40 miles wide. The mean annual temperatures in the coastal lowlands and

the highest mountain districts respectively are 78° and 68°F. There are only slight seasonal and daily fluctuations. The north-east trade winds blow almost continually, but the climate is decidedly variable when the amount and distribution of the rainfall are considered. The mean annual rainfall varies from 26 in. in places on the south coast to 200 inches in the north-eastern mountains, conditions ranging from semi-desert to tropical rain forest. The evaporation ratio is very high.

The virgin tropical forests have been almost entirely replaced by cultivated land, and farming on steep slopes for several hundreds of years has led to great losses of soil through erosion. The island has well-defined regions of tropical forest, grass, swamp and desert; in each of these areas different soils and different types of agriculture have been developed, and each region requires its own special kind of conservation practices.

The average size of farm is about 36.2 cuerdas (1 cuerda = 0.97 acre), but 83.7 per cent of all the 52,790 farms in Puerto Rico are less than 35 cuerdas in size. Only 335 farms or 0.6 per cent of the total are 500 acres or more, but these farms total 663,458 cuerdas, as compared with the farms of less than 100 cuerdas which represent 94.3 per cent of the total number and occupy 744,558 cuerdas of land.

This is one "extreme variation" in type of agriculture. Most of the large farms are under the control of corporations and are mostly planted to sugarcane; they are generally situated on the rich alluvial coastal lands and the interior valleys. Thus, the small-farm type of agriculture, growing crops such as tobacco, pineapples, etc., with the soil clean cultivated and left bare several times in the year, occupies the steep-sloped mountain sides of the interior.

The table on p. 14 of this special issue of *Soil Conservation* indicates the results of observations of the relation of plant cover to the control of erosion and run-off averages, taken from seventieth-acre plots on slopes of 35 to 42 per cent at the Mayaguez Research Station. The surface treatments compared were desurfaced soil, fallow soil, sugarcane (in holes or in furrows), sweet potatoes, jackbeans followed by field beans, squash, molasses grass, Bermuda grass, Guinea grass, sour paspalum, and green cohitre.

The population of the island is now so dense that it is necessary to raise crops on all available land, with the result that the area under pasture of one type or another has suffered. Near the larger centres, the numerous dairy herds are provided with pasturage supplemented by green feed. The size of the pastures and the quality of the feed in the pastures vary considerably. In certain parts, the pasturage consists mainly of planted guinea grass. Working animals are pastured until the beginning of the sugarcane harvest, when they are fed on cane leaves. At the end of the harvest season, they are pastured again, or taken to woodland pastures higher up in the mountains.

In his article on pastures, H. W. Alberts classifies the species found in native pastures as wet lowland, moist lowland, moist upland and dry upland types, and as volunteer grasses occurring on lands during the intercropping season, annuals which appear soon after the completion of intertillage of such crops as sweet potatoes, beans, corn and yautias.

Some grass species are planted only for cutting and feeding green (two varieties of *Pennisetum purpureum* and *Tripsacum laxum*); others are planted for feeding green and for pasture (*Panicum maximum* and *P. purpurascens*); others are not planted, but are cut and fed green (*Panicum maximum*, *P. purpurascens* and possibly *Eleusine indica*, *Paspalum plicatulum* or other palatable species).

In establishing pastures, cultivated fields are abandoned and allowed to pass through the several stages of natural revegetation, or land is prepared by ploughing and harrowing, with the definite intention of establishing a pasture. Owing to the

continuous vegetative growth of tropical pasture grasses, seeds must be collected by hand when the largest proportion in the inflorescence is mature. Many seeds are therefore immature and the germination comparatively low. The seeds of only a few species are used, including *Melinis minutiflora* and *Panicum maximum*.

A special article is devoted to trailing indigo (*Indigo endecaphylla*), which has spread more rapidly than any other legume, and which is considered promising as a forage and erosion-control plant for Puerto Rico. [See *Herb. Abstr.* 10. No. 4. 1940.]

PLANTS OF THE NAMIEB DESERT, SOUTH-WEST AFRICA

[Reviewer: G. M. Roseveare]

It is mainly to German work that reference must be made for the botany of South-West Africa, in which connexion there may be mentioned earlier work by Schenck (**2, 3**) and Schinz (**4**), and Range's more recent systematic studies of the flora of Namaqualand (**1**). Of especial interest are the ecological studies, with a marked grassland bias, by Professor Heinrich Walter, of the Botanical Institute, Technical College, Stuttgart, who visited South-West Africa in 1935 and 1937 (**5, 6, 7, 8**). It is hoped that in due course it may be possible for the Bureau to present his findings in suitable form.

Anatomy of Desert Plants

On his 1935 visit Walter devoted his attention to the Namieb Desert, which runs stripwise right down the coast of South-West Africa and owes its characteristic prevalence of fog to the cold Benguella Stream washing the shores of that country. From the material, consisting of living plants, herbarium specimens and plants in spirit, brought back by Walter, one of his students, Erika Zemke, now presents a study of the anatomy of certain types of plant characteristic of different localities in one and the same desert region (**9**). She notes at the outset that although a large number of anatomical studies of plant species from various arid regions are already in existence, they have generally been made without any exact knowledge of the locality or of the ecological conditions of the region in which the plants are distributed. Deserts were regarded as entirely arid regions, and endeavours were made to see, in the anatomical characters of the plants, adaptations to the extreme conditions postulated. But research of the last few years has shown increasingly that the desert, from an ecological viewpoint, is by no means a uniform region, that here, as elsewhere, the habitats of plants may be very different in regard to water relations, and that therefore the physiological and ecological behaviour of desert plants is also by no means uniform. In studying plants from the Namieb Desert, Zemke had the advantage of Walter's previous ecological study (**5**). She studied in addition, for purposes of comparison, some similar plant types which came either from other parts of South-West Africa or from South Africa, that is to say, in the latter case from a region with a more humid climate, but from localities which exhibit conditions similar to those found in the Namieb. Thus it was possible to compare the anatomy of species (a) which occur in the same climatic region under different local conditions, and (b) which grow in different climatic regions, but under similar local conditions. In studying the anatomy of the plants, particular importance was attached to quantitative measurements (the number of stomata, size of stomata, thickness of the epidermis and cuticle).

The Namieb Desert

Walter's description of the Namieb is summarized as follows. "The Namieb is an extreme desert region, distinguished by very sparse, spasmodic precipitation and a great poverty of vegetation. Rainfall in the coastal region is often lacking for several years, it is greater towards the interior of the country, but hardly reaches an average of 100 mm. even at the inner limit of the desert. A peculiarity of the Namieb desert is the great frequency of fog in the part near the coast, conditioned by the cold Benguella Stream which washes the shores. Walter therefore describes the Namieb as a "fog desert," but notes at the same time that, although atmospheric moisture on the coast is greatly increased through the fog, the amount of water received by the soil through the fog is in general too little to be of any use to vegetation. It is only possible for plants to absorb water through the roots in places where there are smooth rocky walls on which the fog is precipitated and the water runs down. That higher plants are able to absorb fog water so freely through their aerial organs that they can exist without soil moisture, is improbable in the case of the Namieb plants. Towards the interior of the desert, air moisture diminishes rapidly and gives way to an extreme aridity. But even on the coast the air can become very dry and hot when there are east winds.

The second factor which is of importance for the vegetation is, in addition to the aridity, the saltness of the soil. This also diminishes from the coast inwards. It is in general greater in the depressions than in the higher parts of the region. Places where the soil water comes through to the surface are particularly inclined to saltings.

Five Types of Locality

The following types of land may be distinguished. (1) Rocky localities of the outer Namieb. These are mainly ridges of marble, quartzite, and diabase, which furnish the most favourable localities for the interesting succulent associations of the outer Namieb. Through the fog precipitating on the rocks, water conditions here are more favourable than in the plains. To this it should be added that these localities are the least salt. (2) Plains of the outer Namieb. They are distinguished by very extreme conditions. The fog precipitation wets the surface only, and evaporates immediately as soon as the sun appears, without leaving any soil moisture available to the plants. In addition the soil has a fairly high salt content. As a rule these parts of the desert are entirely devoid of vegetation, but after the heavy rain of 1934 they were colonized by a transitory growth of *Mesembryanthemum*. (3) Brackish riviers, or dried water courses, of the outer Namieb. ["Riviers" are defined by Walter as "the eroded valleys of rivers which carry water periodically only, but are otherwise dry." (**5**. p. 61).] These are definitely moist localities with a ground water table frequently less than 1 metre below the surface. Through capillary action the soil is throughly moistened. The ground water itself is only a little brackish, nevertheless through the evaporation of water so much salt accumulates in the surface of the soil that a crust is formed. All the species growing here are halophytes and succulents, with a few non-succulents also." Among the plants studied is the grass *Sporobolus pungens*. "(4) Plains of the central Namieb. Conditions here are not quite so extreme as in the outer part near the coast. Frequency of fog diminishes, but on the other hand there is more rainfall, and in good rain years such as 1934 the whole of the area has a transitory cover of grass. The soil in general has little salt or none at all. In the transition region between the outer salt Namieb and the inner, not salt Namieb is found the most famous plant of South-West Africa, *Welwitschia mirabilis*. Most of the other species are not so strictly confined to this locality." Among the plants studied is the grass *Aristida ciliata* var. *capensis*.

" (5) Non-brackish riviers. These are 'desert localities ' which can no longer be described as arid. In accordance therewith the 'desert plants' here exhibit a quite different habit. They communicate with the favourable water relations of the soil, and only their aerial parts are exposed to the dry and hot desert air. The water attainable by the roots contains little or no salt. This water is seldom actual ground water, but in general capillary moisture retained after the rivers have disappeared from the soil, and protected in the sandy ground from direct evaporation." Among the plants studied here were the legumes *Sesbania aculeata* (under-shrub) and the tree shrub *Parkinsonia africana*.

Sporobolus pungens

The following are Zemke's findings in respect to *Sporobolus pungens*, the grass from the brackish rivier region of the outer Namieb. Measurements (leaf) : thickness of cuticular layer, 2 to 3 μ ; thickness of the outer cellulose wall, upper surface 2 μ, lower surface 5 μ ; number of stomata per mm². (lower surface) 77 ; size of stomata (length by breadth, in μ) 21 × 7.

The leaves, which grow to a length of approximately 12 cm., roll inwards when there is a lack of water, as do the leaves of many xeromorphic grasses. The upper surface of the leaf—broad at the base and running up to a point—is ribbed, the lower surface quite smooth.

The epidermis of the lower surface of the leaf is somewhat strengthened (cellulose wall 5 μ, cuticle 2 to 3 μ), but the ribbed upper surface has only a few thickened and slightly cutinized papillose epidermal cells. The stomata, which are not sunk in, but appear to be on account of the papillose protuberances of the neighbouring cells, are situated in the furrows. In addition, stomata are also found in relatively large numbers (77 per mm².) on the smooth lower surface in places where the assimilation tissue reaches as far as the epidermis. The salt-secreting glands, situated as a rule at the sides of the leaf ribs, consist of a slightly cutinized epidermal cell and of a further large cell situated below it and already half embedded in the assimilation tissue. Through each leaf rib runs a vascular bundle that is accompanied on the upper and lower side by a strong sclerenchymatous cord of fibres and is enveloped in assimilation tissue, as Volkens (*Jb. bot. Gart. Berl.* 3. 1884) and Holm (*Beih. bot. Zbl.* 11. 1902) have already noted in the case of other species of *Sporobolus*. A ring of small, lignified cells in close juxtaposition surrounds the conducting bundle. As a rule only the stronger nerves possess this lignified sheath, while in the weaker bundles unlignified cells adjoin the outer large-celled chlorophyll-conducting parenchymatous sheath.

Aristida ciliata

The measurements recorded for the leaf of *Aristida ciliata* (Desf.) var *capensis* (Trin. et Rupr.) are shown in the table on p. 187. This grass, generally found in a withered condition, covers the salt-deficient, arid areas of the inner Namieb. It generally forms patchy swards only, seldom a close grass cover. It greens only in the rainy season, proceeds to the flowering stage and ripens fruit, and then dies soon afterwards. Its short, narrow leaves are bristly, and roll up even more than those of *Sporobolus pungens*. The lower surface of the leaf in this grass also is smooth, while the upper surface exhibits six to eight ribs.

In anatomical structure *Sporobolus* and *Aristida* correspond to one another in all the most important points. They have been examined already by Volkens [The flora of the Egypto-Arabian desert], 1887, and Holm (*loc. cit.*). In this case also a arge-celled parenchymatous sheath envelops the vascular bundle. The stronger

nerves are further surrounded by a sheath consisting of slightly lignified, thick-walled cells. But, according to Holm, in the *Aristida* species with feathery awns a genuine vascular bundle sheath is lacking, so that it is a question here of a greatly thickened "mestome" parenchyma that simulates a genuine sheath. Narrow-celled sclerenchymatous fibres in broad strands accompany the conducting bundle on both sides. The epidermis cells of the lower surface of the leaf are almost smooth, while those of the upper surface appear to be moderately protuberant. The rolled-in leaf surface is, in addition, covered with short, hooked hairs. The outer walls of the epidermal cells of both leaf surfaces are hardly thickened. The stomata are not sunk in, and are present on the outer and inner leaf surface in very small numbers (13 per mm^2.).

Sesbania and Parkinsonia

Characteristic of the non-brackish riviers of the inner Namieb are the undershrub *Sesbania aculeata* and the woody *Parkinsonia africana*, a tree-shrub reaching a height of 6 metres. *Sesbania* has narrow, imparipinnate leaves approximately 6 cm. long. In *Parkinsonia africana* the leaf pinnae are reduced to small, scarcely perceptible scales, which are attached to the stem-like leaf rachis. The leaf pinnae of *Sesbania* are of dorsiventral structure, with two to three-layered palisade tissue on the upper surface and under it spongy parenchyma. Under the epidermis, and further inside also, are situated great quantities of very large tannin idioblasts with yellow-brown content. The scaly leaves of *Parkinsonia* exhibit a central vascular bundle in a mesophyll tissue, that on both sides is developed in peripheral palisade form. The great leaf reduction in this species makes co-operation of the parts of the axis necessary in assimilation. In younger parts of the shoot we find under a two-layered epidermis a well developed palisade tissue rich in chlorophyll. Further in lies a group of large vascular bundles, which are surrounded by a ring of smaller conducting strands, also isolated; all have heavy sclerenchymatous covering on the phloem side. *Sesbania*, on the other hand, exhibits a broad xylem enveloping the central pith. In the primary cortex of young shoots, with thickened collenchyma, lie isolated groups of sclerenchymatous fibre accompanied by large tannin sacs; smaller vessels of this kind are also found in the pith.

The pinnules of both species possess one-layered, slightly cutinized epidermis. In *Sesbania* the cellulose walls are somewhat more thickened (6 to 7 μ), in *Parkinsonia*, on the other hand, only a little (3 μ). The stomata in *Sesbania*, not sunk or only slightly sunk, are very frequent, for example, on the upper surface 160, on the lower surface 194 stomata per mm^2.; the stomata here, it is true, are particularly small (19 $\times$ 10 μ). Stomata are present also, in accordance with their assimilatory function, on the shoot of *Parkinsonia* (48 per mm^2.), where they are somewhat sunk in the rather thickened and slightly cutinized double epidermis. Young shoot sections in *Parkinsonia* exhibit separate, fairly long hairs. For measurements, see the table on p. 187.

Common Characters Related to Local Conditions

The following are the general conclusions drawn. "As a rule, the plant species of one and the same locality possess a fairly large number of common characters, which have a certain connexion with the local conditions.

Thus for localities in the outer Namieb, the succulence of the plants is the most outstanding character. It may be a matter of stem succulence or leaf succulence, and in both cases we find extreme types, as exhibited, for instance, by the globose *Trichocaulon Dinteri* and *Lithops*, which belongs to the spheroidal *Mesembryanthemum* species. This is a locality in which, it is true, extremely little water is supplied to the plants, but on the other hand this little water is received at more or less regular

intervals through the prevalent fog. These are conditions which the succulents in particular are most well fitted to utilize. They rapidly absorb the little water available by means of their shallow root system, store it, and make use of it extremely sparingly. This results in low vital intensity, which is most clearly expressed in the sparseness of the stomata, the average number of which is 20 to 25 per mm^2. At the same time it must be remembered that the surface development is very small, that is to say, each stoma is responsible for the aeration of a very considerable bulk of tissue.

Cuticular transpiration is extremely little. Boss (1935) gives the daily loss of water in *Lithops* as 0.3 per cent, Walter gives that for *Cotyledon orbiculata* as 0.8 per cent (1936). Engmann (1934), in his experiments with *Mesembryanthemum* species, found that there was an initial daily loss of 1.5 to 2.6 per cent, which fell in subsequent days to 0.3 to 0.5 per cent and remained at this level for twenty-six days. The thickness of the cuticle and of the outer wall of the epidermis unfortunately once more proved an unreliable measure of the resistance of the cuticle to transpiration. In *Cotyledon* and in most *Mesembryanthemum* species, for example, the cuticle is especially thin, although it is just these species which are very effectively protected from the giving off of water.

Still more extreme are the local conditions of the plains of the outer Namieb. The conduction of water through fog is less. At the same time there is a salting of the soil. Only a few *Mesembryanthemum* species are able to thrive in this region. To the characters of the succulents there is united in these species the capacity for tolerating very high concentrations of salt in the cell sap without injury.

The plants of the brackish riviers are typical succulents, for which salt relations are perhaps more important than water relations. The absorption of salt is no passive process, directly dependent on the absorption of water, but we do not yet know how the absorption of salt is regulated. It is therefore useless for the present to seek relations to the number of stomata, development of the epidermis, etc. Walter in 1936 drew attention to the fact that, in general, the species which store chloride only are marked succulents, while the species which in addition store much sulphate are little or not at all succulent. Those plants also which excrete salt are probably in general less succulent.

The plants of the plains of the central Namieb belong to a quite different type. *Welwitschia*, on account of its peculiar systematic position, we shall disregard altogether. *Myrothamnus* also, as a poikilohydrous species, has a peculiar physiological position. All the other herbaceous or dwarf shrub plants, on the other hand, are adapted to entirely different local conditions than are the previously mentioned groups. Fog precipitation no longer plays a part. The salt factor is eliminated. The plants depend, rather, on the infrequent precipitation of the rainy season. It is then necessary for them to make as intensive use as possible of the soil moisture, as long as it is present. In contrast to the succulents, a specially high vital intensity is characteristic of these species. This is expressed in the enormous density of the stomata, which can be rightly valued only when it is remembered that the leaves of these species are relatively thin, and that the stomata are fairly regularly distributed on both sides of the leaves. Aeration must therefore be very good.

Most of these species also possess, in the leaves, tissues which may be described as water storers, but the storage of water is very little. It is of no importance for persistence through times of drought without absorption of water from the soil, but probably serves to mitigate somewhat the daily variation in the water supply of the assimilation tissue. The covering of hair so generally found in these plants may perhaps have a similar significance. That, of course, does not hold good for the glandular hairs. Very characteristic of these species, as in general with sun species,

Development of the epidermis, and number and size of stomata in plants from the central plains

	Thickness of the cuticular layer μ	Thickness of the outer cellulose wall μ	Stomata: Number per mm² Upper surface	Stomata: Number per mm² Lower surface	Stomata: Length × breadth μ
Welwitschia mirabilis ..	10	7.5	98	144	24 × 12
Aristida ciliata	1	upper 1-2, lower 3	—	13	32 × 11
Lyperia litoralis	1	2–3	56	56	31 × 17
Chaenostoma corymbosum	1	4	42	68	26 × 15
Justicia arenicola	1-2 (4)	1-2	119	110	19 × 13
Petalidium variabile ..	1	14-16	193	183	27 × 18
Helichrysum roseo-niveum	1	5	94	126	24 × 14
Tripteris arborescens ..	1	2.5	136	132	25 × 12
Gazania varians	1	25-27 upper	approx. 64	150	— —
Myrothamnus flabellifolia	1-3	1-3	64	78	27 × 12

is the equifacial leaf structure, which is probably connected with the strong reflection from the desert soil.

If these plants are to be described as xerophytes, it is in quite a different sense from the sclerophyllous plants to which the trees and shrubs growing along the non-brackish riviers belong.

As a matter of fact, local conditions here have much in common with those of the typical sclerophyllous vegetation. The sclerophyllous plants, for example, those of the Mediterranean region, are adapted to dry summers, that is to say, high insolation and low humidity, together with adequate soil moisture emanating from the winter rains and penetrating to great depths. We find very similar conditions here, except that the soil moisture does not come directly from precipitation, but rather from the water, retained by capillary action or stored as ground water, that is brought in the watercourses from the region in which the precipitation fell and continues to flow for a long time as a ground water stream.

Just as in the typical sclerophyllous vegetation, these species also are distinguished by very great density of stomata, and also, like most of the wood plants, by the dorsiventral structure of their leaves.

Development of the epidermis, and number and size of stomata in plants from the non-brackish riviers

	Thickness of the cuticular layer μ	Thickness of the outer cellulose wall μ	Stomata: Number per mm² Upper surface	Stomata: Number per mm² Lower surface	Stomata: Length × breadth μ
Sesbania aculeata	1	6-7	160	194	19 × 10
Parkinsonia africana (shoot)	2	3	48		19 × 9
Rhus mucronata	2.5	upper 2, lower 5	114	88	24 × 11
Salvadora persica	4-5	double epidermis	104	121	21 × 10
Euclea pseudebenum ..	4	6	20	85	27 × 23
Gomphocarpus fruticosus	1	3 (over the water-bearing tissue, 7)	77	367	25 × 17

Where the soil is permanently moist without becoming brackish, mesophytic plants also may be found, if they are able to tolerate the strong sunshine and dry air.

Although, therefore, the plant species of the different localities belong, broadly speaking, to certain ecological and anatomical types, yet one cannot speak generally of the "desert plants" found in the Namieb. The types of the individual localities have hardly anything in common with one another, but are sharply distinguished. It would therefore be useless to look for characters common to all "desert plants," frequently referred to simply as "xerophytes," independent of the local conditions concerned in each case.

Secondary Importance of General Climate

These local conditions, as Walter has repeatedly shown, are much more important for the plants than the general climate. This view is confirmed also by the fact that related species found outside the desert region, even in Tsumeb, but in localities which to a certain extent resemble the desert localities, differ to an insignificant extent only from the desert species. It may therefore be said that plants growing in similar localities but in different climatic regions differ, morphologically and anatomically, much less than plants growing in one and the same climatic region, but in markedly different habitats. In all ecological and physiological or morphological and anatomical investigations, therefore, much more importance should be attached to the local than to the geographical principle. Up to the present, unfortunately, this has often been overlooked."

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NUTRITIVE VALUE OF SOUTH AFRICAN PASTURES

[Reviewer: M. Hall]

Since 1930 the Division of Veterinary Services has been engaged on the collection of data concerning the natural pastures of the Union with special regard to determination of their value as feed for stock. (See du Toit, Louw and Malan, "The nutritive value of the natural pastures of the Union of South Africa." *Emg. S. Afr.* 15. 229-32. 1940. 5 Charts). Samples of pasture herbage have been collected during each month of the year by Government officials from over a thousand selected farms and forwarded to Onderstepoort for chemical analysis. Quantities of phosphorus, lime, magnesium, potassium, sodium and chlorine, in addition to protein and fibre have been determined.

The vegetation chart (fig. 1) shows that the largest portion of the eastern half of the Union consists of grass veld, while the western half is mostly desert shrubs and bushes. In this review reference to grass veld denotes the pastures of Natal, the Transvaal and the Orange Free State, while shrub veld denotes more particularly the pastures of the Karoo area of the Cape Province. Attention is drawn to the fact that shrub veld is on the whole richer than grass veld in the essential constituents referred to above. Further, shrub veld shows no appreciable difference in food value in summer or winter and is more resistant to drought, while grass veld decreases enormously in value during winter.

From data supplied, and assuming a bovine of 800 lb. live weight will consume 16 lb. (dry) pasture per day, it is calculated that for medium milk production a pasture should contain 0.27 per cent lime and 0.10 per cent magnesium. In general, the natural pastures of South Africa contain quantities of these elements essential for normal growth and medium milk production. With regard to potassium and chlorine (on the same basis of consumption for a bovine and on 2.5 lb. pasture per day for a sheep of 100 lb. weight), herbage should contain 0.30 per cent potassium and 0.07 per cent chlorine. These elements are also present in sufficient quantities in the pastures studied. The quantity of sodium necessary for medium milk production is about 0.15 per cent and as this amount is much higher than that present in the herbage, animals should be given a supply of ordinary table salt.

In contrast to the nutritive elements mentioned, phosphorus and protein are deficient in quantity in the grass veld. For stock requirements pasture should contain at least 0.14 per cent phosphorus and 7.0 per cent protein.

During the summer, conditions are not so bad, for the investigation revealed that the average phosphorus content of grass veld in various areas may be anything from 0.12 to 0.17 per cent (Fig. 2). On the other hand, the winter figures for the phosphorus content of these pastures are only 0.05 to 0.07 per cent (Fig. 3). Protein also decreases considerably in the grass veld under winter conditions as compared with summer. In summer grass veld contains 7.0 to 9.0 per cent of protein as against only 3.3 to 4.0 per cent during the winter months (Figs. 4 and 5). In no place and at no time of the year have such low values for both phosphorus and protein, as are present in the winter pastures of the grass veld, been encountered in the shrub veld areas. Indeed, it was found in the course of the year that the phosphorus content of the shrub veld was anything from 0.11 to 0.22 per cent, and the protein content between 7.0 and 10.0 per cent. The information in these charts has been determined by calculating the average value of all the samples collected in the areas concerned during the period November to April to represent the general condition of phosphorus and protein content of the pastures in summer, and during the 6 months, May to October, to indicate winter conditions of these constituents.

VEGETATION MAP OF SOUTH AFRICA

Map adapted from that accompanying Botanical Survey Memoir No. 15, 1935, by I. B. Pole Evans, published by the Department of Agriculture and Forestry of the Union of South Africa.

KEY TO VEGETATION TYPES

FOREST

Evergreen and deciduous bush and subtropical forest ..... Type 1

Temperate evergreen forest ..... (Type 2) 

Evergreen sclerophyllous bush ..... Type 3

PARKLAND

Evergreen and deciduous tree and bush ..... Type 4

Subtropical evergreen and deciduous tree and thorn forest ..... Type 5

Thorn country ..... Type 6

GRASSLAND

Tall grass ..... Type 7

Short grass ..... Type 8

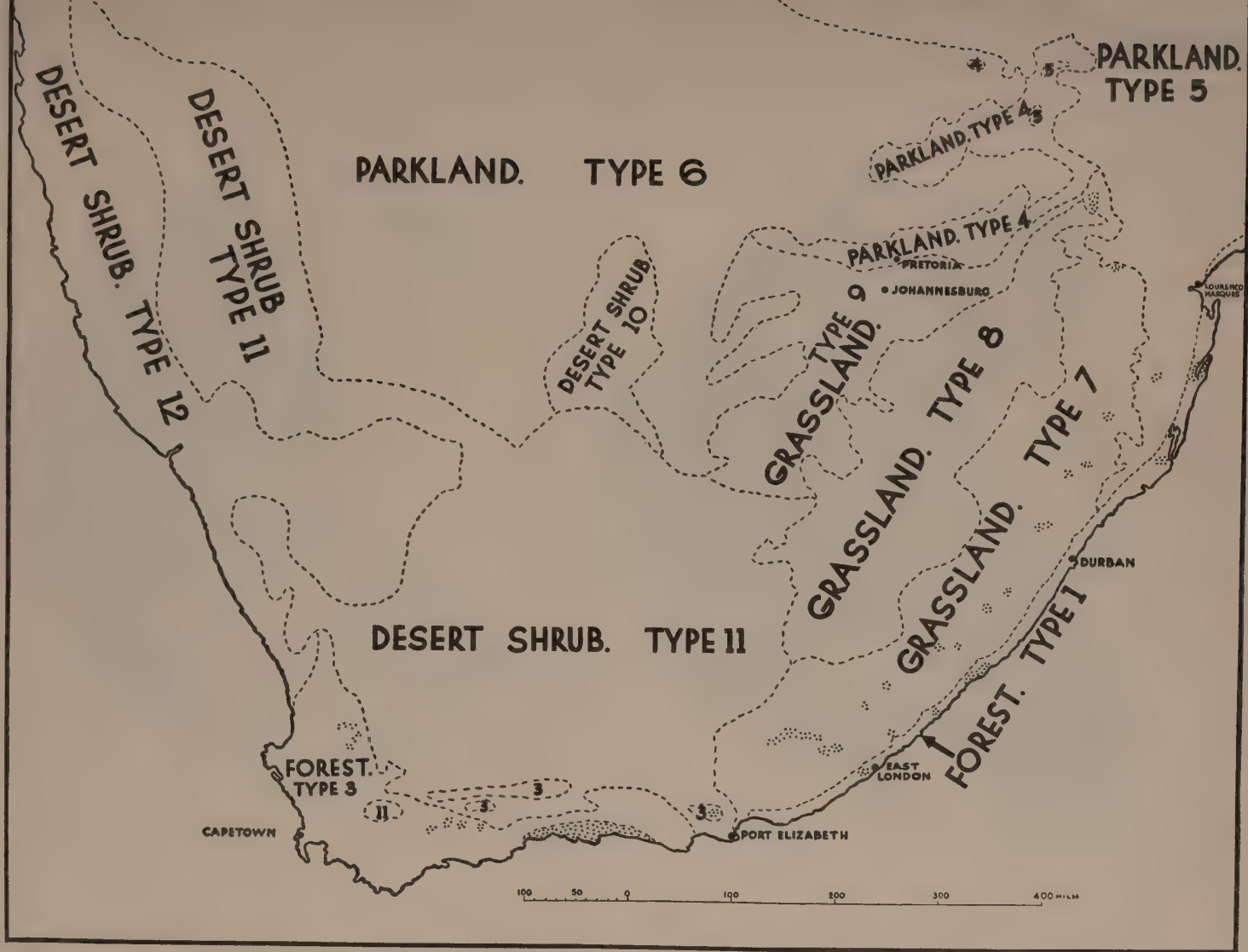
Mixed grass ..... Type 9

DESERT SHRUB

Thorn country and desert shrub ..... Type 10

Desert shrub ..... Type 11

Desert succulents and desert grass ..... Type 12



Adapted from Map by Central Mapping Office, Surveyor General, Pretoria, South Africa.

ig. 1.—Vegetation map of South Africa.

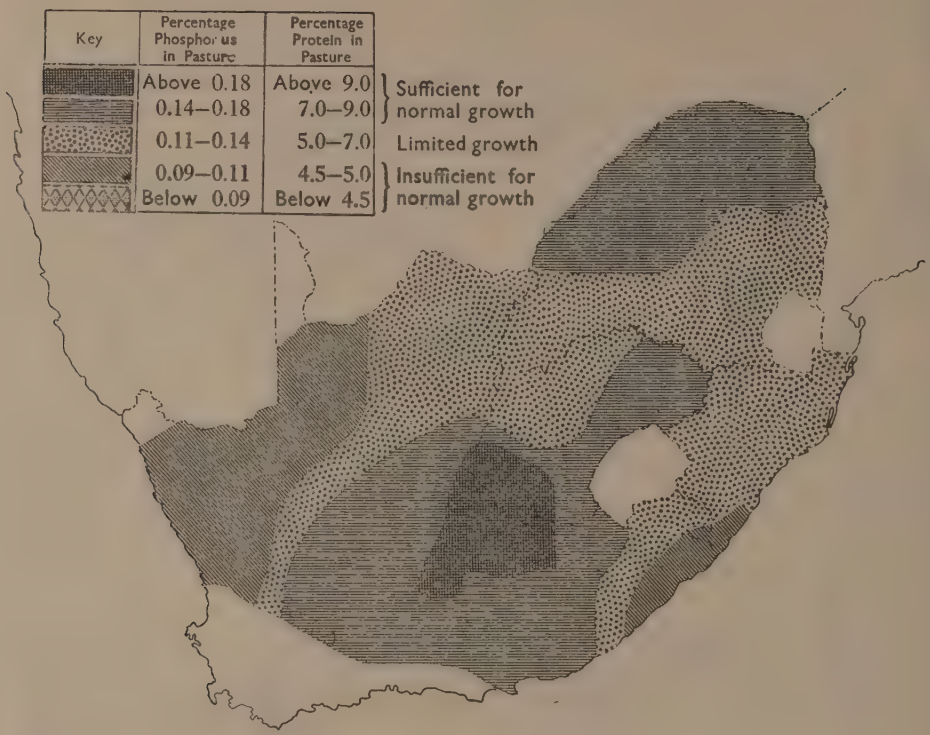


FIG. 2.—Phosphorus content of natural pastures during summer.

FIG. 3.—Phosphorus content of natural pastures during winter.

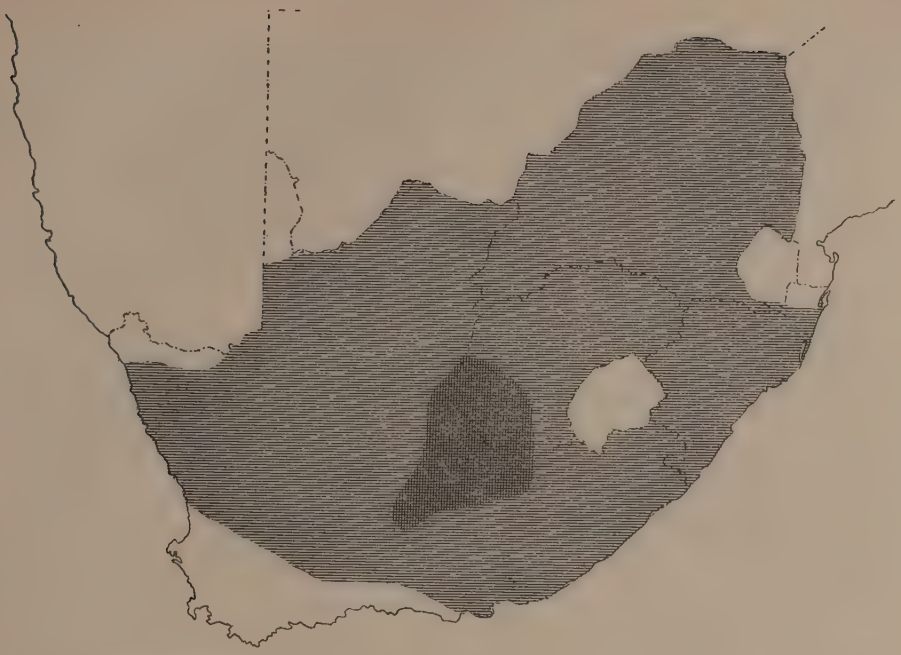


FIG. 4. —Protein content of natural pastures during summer.

FIG. 5.—Protein content of natural pastures during winter.

Thus during periods ranging from 5 to 9 months (depending on locality) the natural grass pastures show a deficiency in phosphorus and protein. On the other hand, under normal conditions of the shrub veld (apart from drought periods) animals seldom suffer from a deficiency of these nutrients. For any locality it should be borne in mind that an apparent deficiency in either of the substances is actually modified by variation in ability of some stock to consume more than the 16 lb. dry pasture per day and by the fact that phosphorus content is at its highest during November to January ; therefore the figure for these months is as a rule higher than the average for the 6 months, November to April. Reference to figure 3 shows the great deficiency of phosphorus in certain areas during winter, but shrub veld under winter rains contains sufficient quantities of phosphorus to obviate the possibility of stock suffering from deficiency of this element.

Figures 4 and 5 show that under normal conditions there is sufficient protein during summer for animal growth, but a serious lack of this constituent occurs in most of the grass veld of the northern provinces during winter. It is stressed that the charts are merely an average reflection of the nutritive value of the pastures on the assumption that there is sufficient food on the veld for animals which must exist on it, and the maps do not necessarily indicate the economic value of various parts of the country for stock farming.

With regard to available energy, it is concluded that an animal derives much less energy from 16 lb. of winter pasture than from the same weight of summer pasture, and future experiments will determine to what extent this reduced available energy in winter pasture contributes to the poor condition of stock during that period.

[See also an article by Louw on " Grass hay as cattle feed. Influence of stage of growth of field grasses on their yield and nutritive value". *Fmg. S. Afr.* 15. 266-7 and 281. 1940, in which work of the Division of Veterinary Services on storage of excess summer grasses in the form of hay or silage is discussed as a means of obviating difficulties due to the impossibility of improving winter grazings in large sections of the summer rainfall area.]

CONTROL OF RAGWORT IN NEW ZEALAND

[Reviewer : M. Hall]

A bulletin has been published describing the investigations instituted by the Ragwort Committee which was set up by the Department of Scientific and Industrial Research in 1936. (New Zealand, Dept. Sci. Ind. Res. Bull. No. 82. Bot. Divn. Publ. No. 2. Botanical aspects of ragwort (*Senecio jacobaea* L.) control. By A. L. Poole and D. Cairns. Wellington, 1940. pp. 61.) Some preliminary work had already been commenced by various Fields Instructors of the Department of Agriculture and their results are incorporated with those from work started in 1937. The new experiments were carried out at the Ruakura Animal Research Station and various localities adjacent to the Waikato District.

To-day ragwort may be found in nearly every county in New Zealand, but in south-eastern counties of the South Island it is not considered as great a problem as formerly. The preponderance of sheep-farming helps to keep the weed in check, and the ploughing of much land to produce winter crops gives newly-sown pasture as

respite of 2 to 3 years before ragwort is likely to reappear in any quantity. Other factors governing distribution are a sufficient rainfall and the presence of medium to light soil types. Spread of the weed is also determined by the boundary between primitive forest association and primitive tussock association. A prolonged dry spell during the summer months causes seedlings to perish in large quantities.

The manner in which severe ragwort infestations modify farming methods and types of farming are noted.

In the section on botanical characteristics it is recorded that the result of interference such as grazing, mowing, etc., is usually to convert the plant into a perennial with a multiple crown and a number of flowering stems. Also in this section of the work the habit of the rooting system in plants growing in pasture land is described. Small pieces of roots have vigorous propagative powers. Experiments have been made which show that complete burial of plants below 5 in. to 6 in. should be effective in killing the roots, and consolidation of the soil is an important factor in preventing excessive regrowths after the plants have been buried. Study has also been made of propagation with special regard to chemical control measures.

Plants cut down in the pasture will form viable seed only if the flowers have been fertilized and are turning brown. In plants which have flowers with all the disk florets fully opened, fertilization may be effected by insects while the plants are still fresh. It is advisable, therefore, to burn all plants cut in the flowering stage.

Germination experiments have demonstrated that there is correlation between germination and moisture conditions and that ragwort will germinate at any time of the year under temperature and moisture conditions prevailing at Waikato. With regard to germination in pastures, it is concluded that a good, dense pasture allows only a small percentage of seed to germinate, and the ultimate percentage survival of seedlings is even much lower. The seed is very resistant to the action of chemical sprays.

Studies on seed dispersal have shown that only a small amount of seed is wind borne. Consideration is given to dispersal by birds, by water, by impurity in seeds mixtures (a frequent means by which the plant is widely dispersed), and by animals other than birds (also an effective means of dispersal).

The life history of the weed has been studied in pastures. This varies considerably with seasonal conditions. Germination will take place at all seasons, but the two most important times for establishment are late autumn and spring. Plants growing in pasture land in various places adjacent to the Waikato and in Southland have been examined to determine percentage of regrowth from the base after flowering. In the former district this was about 33 per cent and in the latter over 50 per cent. If plants are cut in the early flowering stage, large rosettes are formed at the base of the cut stem and these are present in the pastures during the winter months. They constitute a danger from the stock-poisoning point of view.

Experiments on mechanical interference with the plants show that chipping or spudding increases the plants' strength, because new shoots are given off from cut roots. Deflowering stimulates fresh crops; cutting at an early flowering stage does not kill the plants, but cutting when the first seed has set kills a percentage of them; it is not advisable to leave plants until they have set the first seed. Defoliation is an inadequate method of eradication, but pulling gives 55 to 65 per cent control. Use of the flame-thrower seems promising but final figures on this test are not yet available. Trials on control by sheep have shown that the stock alter infestation from large rosette and flowering plants to a number of small plants 2 to 3 in. across and these occupy a smaller percentage of the pasture. Sheep should not be kept on badly infested areas, otherwise losses from poisoning would occur, but by carefully

controlled grazing (alternating the flock from infested to clean pastures), sheep may be kept in normal health. Experiments on control by cultivation are still in progress.

The bulletin concludes with recommendations for the problem in relation to a relatively clean area, to a badly-infested and a very badly infested farm respectively.

[See also Bull. 27 of the Herbage Publication Series, pp. 144-57, for articles by E. Bruce Levy on "Pasture weeds", and by D. Miller on "Biological control of noxious weeds of New Zealand."]

PHOTOPERIODIC ASPECTS OF PHASIC DEVELOPMENT

According to Professor W. F. Loehwing (1939) of the State University of Iowa, Iowa City, photoperiodic studies made during the last five or six years have indicated that it is desirable to subdivide the photo-phase into an initial flowering phase and a gametogenic phase (the formation of viable pollen), as the optimal photoperiods for these phases have been shown to differ.

There is evidence also that initiation and development of pistillate and staminate flowers or even of organs require different photoperiods and some important physiological differences of sexes have been detected. If the flower fertility is to be looked upon as the criterion of photoperiodicity, the conditions may be different from those promoting the inception of primordia. Furthermore, not only do the photoperiods for development of pollen and embryo sac differ one from another, but they in turn also differ from those of the post-fertilization processes. This fact has been recognized by many investigators since the work of Eguchi (*Herb. Abstr.* 9. Abs. 1536). Further, according to Loehwing, the thermo- and photo-phases are not as distinct qualitatively as Lysenko claimed and they may partly overlap, at least in some plants, as shown in experiments (Wöber, 1936, Harder, 1936) in which photoperiodic induction of seeds and seedlings could be effected at low temperature vernalization; no readily recognizable criteria of the completion of the thermo-phase and initiation of the photo-phase could as yet be established.

Loehwing considers that developmental processes are not as rigid as claimed by the supporters of the theory of phasic development and indisputable cases of rejuvenation of plants when the environment was changed were frequently reported. Another aspect of reversion of development is thought to be provided by Gilbert's researches (1926, 1934) with *Xanthium*, the plant changing its photoperiodic category as affected by concurrent temperature. Finally, it is held that the conception of florigen as advocated by Čaĭlahjan and others may be challenged in the light of Melchers' researches (1939) with *Hyoscyamus niger*.

This discussion by Loehwing is based upon certain misconceptions as far as the theory of phasic development is concerned. Admittedly, this theory is incomplete and imperfect and certainly requires critical revision, but if an attempt is to be made in this direction it is necessary to start with the theory as postulated by Lysenko and his associates and followers. Unfortunately, it must be noted that both the theory as discussed by Loehwing and the experimental evidence quoted in this connexion have little in common with the theory of phasic development and the experimental evidence upon which it has been based. Space does not permit a lengthy discussion, but some of the misconceptions which have arisen in this paper may be touched upon.

Loehwing seems to lay particular emphasis upon the photoperiodical "difference

between the thermo- and photo-phases of plant growth" (differentiation in McDougal's terminology). This discussion conveys the impression that plant development, according to Lysenko and his associates, consists merely as it were of these two phases. Apparently, for this reason the author considers it necessary to subdivide the second half of phasic development (the photo-phase) into "a flowering and gametogenic stage." Regardless of what has been written concerning the third (gametogenic) phase which, according to Kiričenko (1934), Kraevoĭ and Kiričenko (1935), Kiričenko and Bassarskaja (1934), and Whyte (1939), follows immediately after the photo-phase in a favourable environment, Loehwing seems to transfer this phase to the photo-phase and then suggests that this combined phase should be subdivided into "a flowering and gametogenic stage."

The third (gametogenic) phase, in so far as it concerns *Triticum erythrospermum*, was shown to differ from the preceding photo-phase, first of all, in the duration of the critical photoperiod (in Garner's terminology) and then in the length of the phase. According to Meljnik (Lysenko, 1932b), the critical photoperiod of the photo-phase was about a 12 to 14-hour day, while the critical photoperiod of the third (gametogenic) phase was, according to Kiričenko and his associates, about a 6-hour day; moreover, the length of the photo-phase, that is, of the period characterized by a critical photoperiod not shorter than a 12 to 14-hour day, was, according to Meljnik, about 20 days or more, while the length of the gametogenic phase was, according to Kiričenko and his associates, quite conspicuously shorter.

The basal discrepancy between the theory of phasic development and that visualized by Loehwing lies, however, not in the minor or major details, but in the completion of the fundamental principles. It would seem that Loehwing considered everything connected with the initiation and growth of the floral and gametogenic organs as development, and everything concerning the growth of the vegetative organs as growth, thus following the lines of McDougal, Klebs and even Ljubimenko, but not the theory of phasic development. According to this theory, the distinction between growth and development is rather rigid, and yet the two phenomena must not be regarded as being in contradistinction, as frequently misrepresented by some investigators particularly in connexion with reversibility. Growth, according to Lysenko and his associates, is regarded as macroscopic changes in any organ irrespective of its developmental phase or "destiny," while development consists of certain internal readjustments in the physico-chemical composition of the protoplasm which predetermine the morphogenesis of the tissue, that is, the direction and type of growth.

In confusing these two most important concepts in the theory of phasic development in his photoperiodical analysis, Loehwing repeated ideas which were once advocated by Ljubimenko (1932) and which were criticized by Lysenko (1932b). Because of this confusion he gave "unspecified" materials on "flower physiology" while all efforts should be directed, as Loehwing felt himself, towards the discrimination in the large amount of experimental evidence available between the photoperiodic responses related to development and those connected with growth.

The fact that, concurrently with the progress of the photo-phase, floral and even gametogenic organs are usually initiated and developed must not be regarded as indisputable evidence that the latter, as it were, constitute the former. The initiation and growth of floral primordia are based upon internal readjustments, that is, upon the quality acquired by the tissues during the preceding phases, and not necessarily upon the quality acquired during the photo-phase. That these two phenomena are not identical and can be separated on the time scale may be inferred from the fact alone that the photo-phase can be completed in certain plants during vernalization (Ljubimenko 1932, Lysenko 1931), thus changing the sequence of the relation of plants to photoperiods.

It is rather difficult to understand why and how the experiments of Harder (1936) and Wöber (1936) did actually suggest "evidence of overlap" between the thermo- and photo-phases which "Lysenko originally considered . . . qualitatively distinct." In these experiments, plants *previously vernalized* at low temperatures were grown in different photoperiods, and, furthermore, Harder took special care to emphasize that the efficacy of vernalization of long-day plants in subsequent short photoperiods was *relatively greater* than in long photoperiods, although, as the experimental data show, flowering was *actually earlier* in long photoperiods than in short photoperiods.

Vernalization of the thermo-phase and the subsequent light-sensitive phase or phases under the same temperature is, of course, quite possible, although not concurrently or with overlap, but in a strict succession, never reversed or altered. It must be remembered that the temperature ranges at which the thermo-phase and the light-sensitive phases can develop with greater or less ease may overlap in many plants, although the optimal temperatures may be quite distinct. Not only has there never been evidence of overlap between them, but also there is evidence that the thermo and photo-phases are more widely spaced than they were formerly considered to be, the discovery of an intermediate phase requiring darkness in long-day plants (McKinney and Sando, 1933; Mackov et al., 1936; Eremenko, 1936, 1938 and 1939; Whyte and Oljhovikov, 1939) having made it possible to claim the following succession of ecologo-physiological phases during the life period under discussion . . .⟶thermo-phase⟶scoto-phase⟶photo-phase⟶ . . .

If to this succession is added the subsequent gametogenic phase, and the comments made by Whyte (1939) are borne in mind, the development, at least of an annual plant, may be said to comprise five ecologically distinct phases, that is, the exact number anticipated by Lysenko in 1934. Thus, there was no need to subdivide the photo-phase into a flowering and a gametogenic phase.

Finally in speaking of reversibility, Loehwing states that "Lysenko and Whyte (1939) have also postulated the irreversibility of phases". Referring to certain cases of alleged "devernalization with age and unduly prolonged low temperature" as well as secondary flowering and "also cases of vegetative proliferation" (which Whyte described as "rejuvenation of the plant as a whole"), Loehwing accuses them of maintaining excessive rigidity of the concept regarding irreversibility. Actually, Whyte discriminated between two conceptions, namely, "rejuvenation of the plant as a whole" and "irreversibility of the physiological properties acquired by meristematic tissues". While the former has nothing in common with true reversibility as has been claimed repeatedly since Klebs, the latter, that is, "the faculty to proceed in two diametrically opposite directions" . . . . . "the progressive changes maturing the tissue and the regressive changes rejuvenating the same tissue" . . . . . has not been proved experimentally. For "there can be little doubt as to the real nature of the 'reversal' effect of over-vernalization and seed drying", a conclusion which must be admitted is anything but "rigidity" of the conception.

"The concept of phasic development of plants" as Loehwing has rightly stated, "has in less than a decade profoundly influenced the fundamental philosophy of plant growth" and it is for this reason alone that we venture to discuss these deviations from the theory as it stands to-day.—M.A.O.

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PHASIC DEVELOPMENT IN HERBAGE PLANTS

VERNALIZATION of seeds or seedlings is generally associated with an attempt to obtain a yield of seeds or fruits as early and perhaps as large as possible. This is an under-estimation which is due chiefly to the fact that the principles of vernalization and phasic development in their wider aspects have been studied almost exclusively on plants the economic value of which is entirely or chiefly confined to their grain yield. Even when dealing with herbage and forage crops, the seed yield has been the most prominent feature under investigation; although it is the growth and formation of forage which is the important aspect in the cultivation of forage crops, this has been regarded as of secondary interest, if it has been touched upon at all.

The obvious question arises for what purpose, other than the production of seed, the vernalization of forage plants may be utilized, particularly in view of certain reports and concepts to the effect that the yield of forage is reduced by vernalization. For instance, in experiments with *Vicia villosa*, M. S. Kalantyrj (cf. *Herb. Abstr.* 10. Abs. 265-6. 1940) reported that the yield from vernalized plants was reduced to 149.2 dz. per ha. compared with 159.6 dz. per ha. from unvernalized plants. Such a result would naturally be obtained when the crop is cut during flowering of the unvernalized plants.

If, however, the dynamics of growth are examined more closely, it will be found that in all plants, irrespective of their time of flowering, the rapidity of growth increases to a maximum at the time of flowering or thereabouts and then begins to fall. It is not until this period of full growth is over that the plants are usually cut for forage. As a result of vernalization, plants will begin to flower earlier, and sometimes much earlier than unvernalized plants. That is, inasmuch as some of the phenological phases are a morphological expression of physiological advances (developmental phases) towards sexual reproduction, the vernalized plants start and com-

plete all phenological phases, and consequently also the period of full growth, earlier and perhaps more rapidly than unvernalized plants. For instance, in experiments with single and double-cut red clovers, Ševčenko reported that stems ceased to grow in 67 to 68 days in vernalized plants, whereas the figure for unvernalized plants was 96 to 97 days when the latter were sown at the same time and grown under similar conditions.

If we compare the growth rate curves during the first half of the season we shall see that vernalized plants grew more rapidly than unvernalized plants ; then, as they flowered earlier, their growth ceased earlier, while the unvernalized plants could

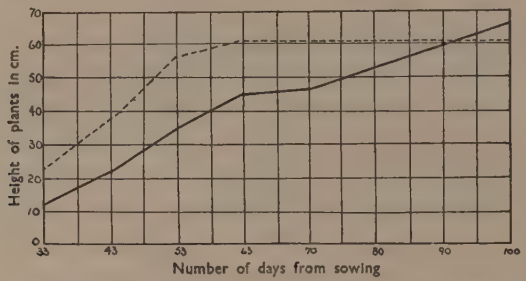

FIG. 1.—Curve representing the growth rate of *Vicia sativa* (Kurskaja 713). Continuous line = unvernalized. Broken line = vernalized.

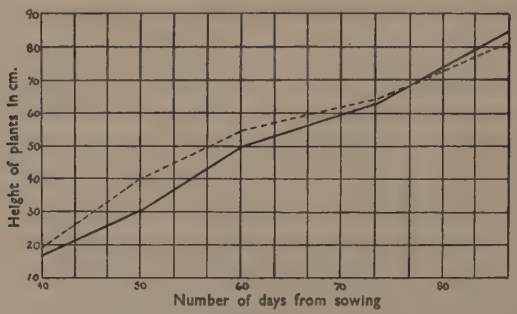

FIG. 2.—Curve representing the growth rate of *Vicia villosa*. Continuous line = unvernalized. Broken line = vernalized.

continue their growth and equal or even exceed the vernalized plants in yield by the time they flowered later in the season. Nevertheless, if forage yield is calculated per the unit of time during which it was formed (from sowing to cutting), it will be found that the vernalized plants are superior to the unvernalized plants in vigour of growth and thus in the rapidity of formation of a fully normal yield of forage.

In other words, if vernalized and unvernalized plants are cut during the flowering of the former, the forage yield from vernalized plants will be both larger and more palatable than that from unvernalized plants. Vernalization, therefore, makes it possible to obtain a normal first cut on an earlier date, an effect which may be of decisive importance in some countries when dealing with plants which flower in the year of sowing. The advantage is still greater when we are concerned with plants which produce few or no flowers in the year of sowing, or when the second half of

the season is unfavourable for plant growth. For instance, Vasiljev reported in his pamphlet (Seljhozgiz. Moskva. pp. 20. 1939) that in the Vologda region *Vicia sativa* flowered 10 days earlier when vernalized, producing a hay yield of 31.9 dz. as compared with 23.2 dz. per ha. from unvernalized plants; in the Moscow region vernalized vetch flowered 11 days earlier and produced 25 dz. as compared with 15 dz. per ha. from unvernalized plants; in the Orel region vernalized plants flowered 12 days earlier and produced 89.5 dz. green forage as compared with 63.7 dz. per ha. from the unvernalized plants.

The possibility of obtaining an early cut is of particular importance with mixed sowings whenever there is a difference in the time of flowering between the chief components. Slowly developing (late-flowering) types when grown in a mixture with rapidly developing (early-flowering) types give a low forage yield, or may be for all practical purposes absent in the first cut if this is made in accordance with the readiness of the early-flowering components. On the other hand, if the mixture is cut when the late-flowering components are ready, the forage yield will indeed be increased on account of the increased participation of these later types, but the forage may become too coarse on account of the over-ripeness of the early types. Vernalization of late-flowering components may reduce or even remove this discrepancy in the succession of phenological phases and thus increase the participation of the late types in the first cut, increasing also the forage yield of the mixture without any loss in quality when it is cut in accordance with the readiness of the early-flowering components.

Such an example was in fact reported by Kalantyrj in experiments with a mixture of *Vicia villosa* and oats. When the mixture was cut while the vernalized vetch plants flowered (a fortnight earlier than the unvernalized) the forage yield was increased from 84 to 99 dz. per ha. and there was 5 to 6 per cent more vetch in the mixture.

The acceleration in plant development and growth after sowing, just as the general behaviour of plants from vernalized seeds, should not however be regarded as a direct after-effect of vernalization. The rapidity of development and growth is determined by the environmental conditions. Owing to vernalization, however, the subsequent developmental phases and hence the phenological phases will occur earlier and therefore under different conditions than is the case with the unvernalized plants. Such a shift of plant development on the time scale may have a retarding effect on some of the developmental phases, and an accelerating effect on others. The effect of vernalization may thus be compared with that of a change in sowing date.

The rapidity of development and growth depends primarily upon the time of sowing. Assuming that the thermo-phase was completed during vernalization (not always the case), late spring sowing has proved to be more beneficial for all plants studied hitherto, at least as far as development is concerned.

This does not necessarily imply that it is an advantage in the cultivation of forage crops to sow late, as the growing of plants under better conditions (for development) of temperature and light may accelerate subsequent development, thus curtailing the length of the phenological phases and the period of full growth, with the result that the forage yield may be considerably reduced. The optimal time of sowing of vernalized plants must be established by carefully planned experiments to cover all plants and all regions. Nothing in this direction has yet been attempted anywhere.

The extract from Ševčenko's report gives the first indication of such an effect of the conditions of the period following sowing. By prolonging day length during rosette formation, the period of rosette formation was reduced by 22 days in double-cut clover, but the beginning of flowering was somewhat retarded, although the period of flowering was also curtailed.

Therefore in changing the time of sowing, that is, in forcing plants to complete subsequent developmental phases under different conditions of temperature and light, it is necessary to take into consideration their requirements at different developmental phases.

In other words, we must have accurate information as to the sequence of changes in these requirements as the plants progress towards reproduction ; such information can be obtained only by what is now known as "phasic analysis." If we consider plant development as a succession of complex requirements for definite ecological factors, this study may be regarded as an analysis of the sequence of ecologo-physiological phases.

Phasic analyses of this type have been increasingly employed in the Soviet Union during the past 4 or 5 years (cf. *Herb. Abstr.* 10. Abs. 792 and 795). Not all of these were properly arranged, their chief defect being perhaps that their large scope cannot provide anything other than a general conception, while in this problem it is the details that are important.

The principles upon which this kind of study is based are obvious ; briefly it may be stated that after vernalization of one or two consecutive phases, plants shall be grown for a varying number of days under the conditions required at subsequent phases, and then transferred to conditions favouring, or believed to favour the progress of subsequent phases and flowering, at the same time preventing if possible the development of the preceding phase. The article by Lubenec (see p. 206) is a study of this type, although perhaps not the best in its class. Lubenec attempted to force the plants to complete the thermo-phase before sowing. This would appear to have been unsuccessful, not, as the author thinks, because of the shortness of the thermo-phase in all lucernes, but more probably because the thermo-phase had been completed in all plants during seed ripening. It must be regarded as an indispensable prerequisite in these studies to use not a seed, but seeds grown and ripened under conditions which prevent the vernalization of the thermo-phase during seed ripening on the mother plant or during natural drying in the field in a cold and rainy season.

At a glance such an arrangement would not appear to differ considerably from the so-called "environmental studies" which are so numerous in the agro-biological literature. The significant difference is, however, that with such an arrangement we are not only fully aware of the history of the plant, but also, and this is of the utmost importance, we as it were prepare the plant and while exposing it to a definite complex of temperature and light, we are dealing with a definite ecologo-physiological complex, that is, with a plant at a definite developmental phase with a definite relation to the environment. These general principles may be applied, of course, to the study of any plant, but further complications must arise when forage plants are investigated, as here we are interested in the dynamics of the formation of the forage yield ; thus in these studies we must take the growth rate into consideration, giving particular attention to the beginning and the duration of the period of full growth.

In dealing with perennial plants, another important aspect must not be overlooked, namely, that while changing (on the time scale) the developmental cycle in the year of sowing by vernalization or other means, we thus shift the time of initiation and hence the development of the subsequent developmental cycles in daughter (deferred) shoots. It is not necessary to discuss this question of the "after-effect" of vernalization, as this was done in *Herb. Rev.* 5. 34-6. 1937. It is regrettable that this by no means less important aspect has not received any further investigation since first reported by Zerling and Čepikova (cf. *Herb. Rev.* 2. 137-8 and 3. 36-40), although in the light of subsequent studies in phasic development the effect of shifting the time of flowering in the first year on the subsequent growth, development and well-being of perennial plants has acquired a particular importance, as it has become

known that while plants advance in sexual development, changes occur in their biological properties, such as ability to harden, resistance to cold, drought, etc. These changes may prove to have a disastrous effect upon the perenniality of the plants.

Finally, there is in this connexion yet another aspect of great importance in the application of vernalization and phasic development to forage plants, an aspect which Tužihin has discussed in the form of a thesis (see p. 209). There is nothing unexpected in his conclusions. The significance of time of cutting on the vigour of growth and development of daughter shoots was well established as far back as 1915 by Waters, who showed that the early degeneration of timothy plants was due to the excessively early cutting then practised in the United States ; later in many reports, particularly those by Klapp (*Herb. Rev.* 6. 164-71. 1938) and Smelov (*Herb. Rev.* 5. 132-45. 1937), as well as by Virtanen and Nurmia (*J. agric. Sci.* 26. Pt. 2. 288-95. 1936), this factor was confirmed and further investigated in studies of the localization and dynamics of reserve substances in mother plants and their effect on the devleopment and growth of a new generation of shoots.

In his article, however, Tužihin attempts to consider these well-established facts in relation to the phasic development of the species concerned, an aspect which deserves particular attention, as it has now been more widely admitted that " the concept of phasic development of plants has, in less than a decade, profoundly influenced the fundamental philosophy of plant growth as well as theory and practice in plant physiology, ecology, agronomy and genetics " (Loehwing, *Science.* 90. 552-5. 1939 ; *Herb. Abstr.* 10. Abs. 247. 1940) ; the appreciation of the significance of phasic development and of vernalization must be based upon a correct understanding of the theory of phasic development and brought into actual practice in our agro-ecological and agro-genetical studies.—M.A.O.

VERNALIZATION OF RED CLOVER* — A. Ja. Ševčenko

Single-cut (Central Russian) and double-cut (Ukrainian) red clovers were vernalized and grown according to the scheme in Table 1, the seeds having been received from the Moscow Regional Station of Agronomy, Nemščinovka.

Table 1.

Soaking in water. Vernalization at 3-5°C. for 20 days for single-cut clover (variants 1 and 2), and for 10 days for double-cut clover (variants 7 and 8).		Unvernalized seeds. Single-cut clover : variants 5 and 6 ; double-cut clover : variants 11 and 12.		Unvernalized seeds. Single-cut clover : variants 3 and 4; double-cut clover : variants 9 and 10.	
Sown on July 8		Sown on July 8		Sown on June 18 and 28 when vernalization was begun.	
Normal day. (Variant 2 and 8)	Additional light during night. (Variants 1 and 7)	Normal day. (Variants 6 and 12)	Additional light. (Variants 5 and 11)	Normal day. (Variants 4 and 10)	Additional light. (Variants 3 and 9)

Seed samples of 50 grm. each were placed in muslin bags and their moisture brought to 60 per cent. The seeds were moistened three times, in the morning, at night and in the following morning, one-third of the total amount of water being given on each occasion. After the last moistening, the bags were weighed and placed in a room where the temperature was maintained at 3 to 5 °C. The bags were weighed

*Abridged translation of chapter 3 of the report entitled " Preliminary results in the selection and vernalization of clover," by A. Ja. Ševčenko of the Flax Research Institute, Toržok, U.S.S.R., Published in Mater. Sovešč. Korm. Trav. pp. 20-8. 1939.

every 5 days and if the weight had fallen the difference between the original weight and the weight found in checking was taken as the amount of evaporated moisture, and an equivalent amount of water was then added.

The seeds of single-cut clover were sown on June 18 (variants 3 and 4) of and double-cut clover on June 28 (variants 9 and 10) ; on these days vernalization of the seeds was begun with variants 1 and 2, 7 and 8 respectively. Vernalized seeds were sown on July 8, together with the control (variants 5 and 6, and 11 and 12). All the seeds were sown in finely sifted soil, twenty-five seeds per pot, which were later thinned to four or five plants per pot. Additional electric light of 500 candle power per sq. meter was provided for 60 days during the night hours from 10 p.m. to 6 a.m. Thus, some of the plants (variants 1, 3, 5, 7, 9 and 11) received a total of 480 hours of electric light.

Phenological records were maintained throughout the vegetative season ; mean values are quoted in Table 2.

Table 2.—Phenological data of plant development.

Variants	Type of red clover	Date of sowing	Number of days							
			From beginning to end of seedling appearance	From end of seedling appearance to beginning of rosette formation	From beginning to end of rosette formation	From end of rosette formation to stem formation	From end of stem formation to end of budding	From budding to beginning of flowering	From beginning to end of flowering	Total length of vegetative period
1. Vernalization for 20 days plus additional light	Single-cut clover	July 8	3.0	25.0	20.5	18.5	4.5	5.0	14.0	90.5
2. Vernalization for 20 days no additional light		,, ,,	4.0	25.0	20.5	28.0	5.5	6.0	18.0	107.0
3. Unvernalized seeds with additional light		June 18	3.0	36.0	33.0	23.0	2.5	6.5	19.0	123.0
4. Unvernalized seeds, no additional light		,, ,,	2.0	38.0	81.0	—	—	—	—	—
5. Control, with additional light		July 8	3.0	38.0	30.0	25.5	4.0	3.0	—	(103.5)
6. Control, no additional light		,, ,,	4.0	38.0	—	—	—	—	—	—
7. Vernalization for 10 days plus additional light	Double-cut clover	July 8	2.5	25.5	20.0	20.5	3.0	3.0	14.0	88.5
8. Vernalization for 10 days no additional light		,, ,,	2.5	24.0	42.0	17.0	2.0	1.5	17.0	106.0
9. Unvernalized seeds with additional light		June 28	2.0	54.0	28.0	23.0	3.0	3.0	—	(113)
10. Unvernalized seeds no additional light		,, ,,	2.0	54.0	41.0	16.0	2.0	—	—	—
11. Control, with additional light		July 8	3.0	47.0	27.0	20.0	3.0	3.0	—	(103)
12. Control, no additional light		,, ,,	3.0	47.0	47.0	—	—	—	—	—

Development of rosette

The period from the appearance of seedlings to the initiation of the leaf rosette persisted in vernalized plants of both clovers for 24 to 25 days (variants 1, 2, 7 and 8), while in the unvernalized plants it was 36 to 38 days for single-cut clover (variants 3, 4, 5 and 6) and 47 to 54 days for double-cut clover (variants 9, 10, 11 and 12).

The period of rosette development in single-cut vernalized plants (variants 1 and 2) was 20.5 days, irrespective of day length; the rosette of vernalized plants of double-cut clover grown with additional light (variant 7) developed in the same number of days; the period of rosette formation was prolonged to 42 days (variant 8) in double-cut clover grown from vernalized seeds, but without additional light.

At the same time, in the variants sown on the day when vernalization was begun, the rosette formation of those receiving additional light was prolonged to 33 days in single-cut clover (variant 3) and to 28 days in double-cut clover (variant 9) while the rosette formation of the variants receiving no additional light continued for 81 days in single-cut clover (variant 4) and 41 days in double-cut clover (variant 10).

In the control which received additional light during the night hours (variants 5 and 11), rosette formation continued for 30 days in single-cut and 27 days in double-cut clover. In the control which had received no additional light (variants 6 and 17), the rosette formation remained incomplete in single-cut clover, and continued for 47 days in double-cut clover.

Stem formation.

In single-cut vernalized clover the stems developed in 28 days without additional light (variant 2), and in 18.5 days with additional light (variant 1). Stem formation in the variants from unvernalized seeds grown with additional light progressed in a similar way in the plants sown on the day when vernalization was begun (variant 3), and in those sown at the same time as the vernalized plants (variant 5), whereas no stems were developed in the variants from unvernalized seeds sown without additional illumination (variants 4 and 6).

With double-cut clover the stem developed in 23 days in the variants sown on the day that vernalization was begun, with subsequent additional light (variant 9), and in 20 days in variant 11 sown with unvernalized seeds and grown under additional light, and in variant 7 sown with vernalized seeds and grown in additional light. In the variants grown from vernalized seeds without additional light (variant 8), the stems developed in 17 days, whereas no stems were formed in the control which did not receive additional illumination (variant 12).

Flowering.

Flowering in double-cut clovers vernalized for 10 days and given electric light during the night hours (variant 7) began on September 25 and continued until October 10. Flowering of single-cut clovers vernalized for 20 days and given additional light (variant 1) began on September 27 to 28 and continued until October 12. Flowering of single-cut and double-cut clovers grown from unvernalized seeds without additional light (variants 2 and 8) began on October 9 to 12 and continued until October 25 to 29. Single-cut and double-cut clovers from unvernalized seeds grown with additional light (variants 3 and 9) flowered on October 5 to 28, but the control plants (variants 5 and 11) failed to flower under similar conditions. The lengths of the vegetative period are given in Table 2. It may be seen that in both single-cut and double-cut clovers the shortest vegetative period occurred in the variant from vernalized seeds grown with additional light. The percentage of flowering plants in the different variants at the time of harvest is given in Table 3.

Table 3.—The percentage of flowering plants at the time of harvest.

Variants	Type of clover	Number of plants	Flowering plants	
			Number	Percentage
1	Single-cut clover	16	16	100
2		16	13	81.2
3		16	12	75.0
4		16	—	—
5		16	1	6.25
6		16	—	—
7	Double-cut clover	16	16	100
8		16	13	81.2
9		16	13	81.2
10		16	—	—
11		16	4	25
12		16	—	—

The following conclusions may be formed from these data :

1. Both single-cut and double-cut clovers from vernalized seeds grown with or without additional light during the night hours flower in the year of sowing.
2. The combination of these two factors, vernalization and additional light during the night hours, reduces the period from the appearance of seedlings to the cessation of flowering by 17 days, as compared with vernalization alone, and by 30 to 33 days as compared with additional light alone.
3. The study of phasic development of red clover may render great theoretical and practical differences in (a) the obtaining of an early seed crop, and (b) the speeding up of the processes of breeding.

PHASIC DEVELOPMENT OF LUCERNE* — P. A. Lubenec

Experiments were made in 1936 and 1937 in connexion with a study of phasic development in the chief lucerne varieties grouped under appropriate ecologo-geographical heads to investigate the possibility of :

(1) speeding up flowering, fructation, and seed ripening, and increasing seed yield, more particularly in the year of sowing ;

(2) obtaining two seed crops and two or three hybrid generations within a year and thus discarding hybrids on the basis of their behaviour in the first year.

The following scheme was adopted for these experiments :

(1) Exposing slightly germinated seeds to low temperatures (2 to 3°C.) for 50, 40, 30, 20 and 10 days.

(2) Exposing slightly germinated seeds to high temperatures (35 to 40°C.) for 10 and 5 days.

(3) Exposing fully germinated seeds (seedlings 3 to 5 mm. long) to low temperatures (2 to 3°C.) under conditions of (a) long day (20 hours) for 35, 25 and 10 days, (b) short day (10 hours) for 35, 25 and 10 days, and (c) normal day.

(4) Growing plants under field conditions in (a) long day (20 hours) for 35, 25 and 10 days, (b) short day (10 hours) for 35, 25 and 10 days, and (c) normal day.

(5) Growing plants in the second year under field conditions in (a) long day (20 hours) for 30, 20 and 10 days, (b) short day (10 hours) for 30 days, and (c) normal day.

*Abridged translation from chapter 2 of the report by P. A. Lubenec, of Kuban Exptl. Sta. of the Institute of Plant Industry, Otrada Kubanskaja, published in Mater. Soveš̆č. Korm. Trav. pp. 91-114. 1939.

The seeds of the control plants for all these experimental variants had been soaked and germinated in a corresponding manner. In the chilling experiments, the germinated seeds were mixed with pine sawdust and stored in tin boxes on ice in a cellar.

When plants were grown under field conditions in long, short or normal days, the germinated seeds were sown in rows and the plants exposed to long or short day after the first four or five leaves had appeared on the stems of the first cut, and at the beginning of growth resumption in the second cut. Additional electric light was used in the series exposed to long day at the rate of 100 candle power per sq. metre.

The plants in the short-day series were covered daily with large boxes lined on the outside with pitch paper. Detailed phenological observations were made from the time of sowing until the end of the experiments, on appearance of seedlings, beginning of flowering, setting and ripening of pods, character of growth and vigour of development.

Observations in 1936 showed no difference in the first year of growth between any of the experimental variants which involved exposure of germinated seeds to low or high temperatures for 5 to 10 days, nor in those involving growth of germinated seeds in long, short or normal days at low temperatures, as compared with the control (germinated seeds grown under normal conditions). The plants in all variants attained the same height and began the developmental phases, including budding, flowering and seed ripening, at about the same time. Those plants grown in the field in long, short or normal days exhibited, however, conspicuous differences between the varieties and also in the character of growth, as well as in the onset and progress of the main phases of development and in the vigour of fruiting.

Plants of early lucernes from southern countries (Yemen, Tripoli and Mesopotamia) developed almost simultaneously in long and short days as compared with those in normal days.

With medium lucernes (Grimm-Zaĭkevič, French, New Zealand, Asia Minor and Ukrain. 333), plants in long days were 6 to 10 days earlier in flowering and 9 to 11 days earlier in browning of pods as compared with those in normal day. Plants grown in short day, however, were 5 to 8 days later in flowering and 13 to 15 days later in browning of pods.

Late varieties (Predgornaja from Armenia, Khivian, Semirechian and Daghistanian blue) which had been given long day flowered 14 to 16 days earlier and ripened their pods 13 to 17 days earlier than plants grown in normal day. Plants grown in short days when compared with those in normal day were 21 to 27 days longer in flowering and failed to ripen pods until the late autumn (Table 4).

Differences due to day length were most conspicuous in all lucernes in connexion with the vigour of fruiting (pod setting on a plant). Yellow lucernes set no seed or produced only a few scattered pods in a normal day. Late blue lucerne gave a small seed crop. The yield of medium lucernes varied from average to good. The pod setting of all lucernes improved when grown in long day for 25 to 35 days. Under short-day conditions early varieties had a good pod setting, while late blue lucernes and yellow lucernes either formed few pods or failed altogether.

In 1937, medium and late blue lucernes and yellow lucernes grown in long day gave an average yield three times that obtained in short day, and 2.5 times less than that in normal day (Table 5). The character of the rosettes at the resumption of growth, and the shape of the bush varied with day length. Medium varieties in normal day had a loose rosette ; under long day they formed an erect rosette and bush ; in short day they had a prostrate rosette and a loose bush. Late blue lucernes and yellow lucernes had a prostrate rosette and a loose bush in normal day, and a semi-prostrate rosette and semi-erect bush in long day. Early lucernes grown in short, normal or long days had erect rosettes and bushes.

In the studies of phasic development in lucerne varieties, it was found that all lucernes had a equally short first developmental phase (the stage of vernalization), but differed in the length of the photo-phase. Southern blue lucernes from regions with a moderate climate had a short photo-phase; varieties from Central Europe, North America, Asia Minor, etc. had a photo-phase of average length, and blue lucernes and yellow lucernes from mountainous regions, Eastern and Northern Europe and Central Asia had a long photo-phase.

Table 4. Number of days from resumption of growth to flowering and pod browning in lucerne varieties as affected by 25 days' growth in long, short and normal days ; second cut, 1936.

Name	Beginning of flowering			Beginning of pod browning		
	Normal day	Long day	Short day	Normal day	Long day	Short day
A. Early lucernes						
Yemen	16	15	17	57	55	58
Tripoli	19	18	20	57	56	60
Mesopotamia	23	21	24	61	58	62
B. Medium lucernes						
Grimm-Zaïkevič	25	19	33	69	60	83
French	27	21	33	71	60	84
Asia Minor	31	22	36	74	65	89
C. Late lucernes						
Armenian (Predgornaja)	47	32	69	79	66	failed
Khivian	49	33	71	81	68	,,
Blue from Daghistan	51	37	78	84	69	,,
D. Yellow lucernes						
Kuban yellow	53	34	failed	failed	71	failed
Altai	55	35	,,	,,	70	,,
Krasnokutskaja	50	32	,,	,,	69	,,

Table 5. Seed yield (in grm. per ten plants) from lucerne varieties as affected by 30 days' growth in long, normal and short day ; first cut, 1937.

Name	Normal day	Long day	Short day
A. Medium group			
Grimm-Zaïkevič	1.2	6.1	0.5
French	1.1	3.5	1.1
Asia Minor	1.1	2.5	0.1
Ukrain. 333	2.7	7.3	1.1
B. Late group			
Armenian (Predgornaja)	0.1	1.5	—
Blue from Daghistan	1.0	2.3	0.3
Khivian	0.5	1.5	0.2
Semirechian	0.3	1.3	0.1
C. Yellow lucerne			
Kuban yellow	2.5	7.8	1.5
Maikop yellow	2.2	5.7	1.3
Krasnokutskaja	1.1	4.5	0.2

AFTERMATH FORMATION IN PERENNIAL PLANTS* G. A. Tužihin

Observations on aftermath formation and the developmental cycle of shoots of perennial grasses (Tužihin, 1939) and an analysis of the experimental evidence in the literature (Williams, 1936 ; Koreïša, 1935 ; Smelov, 1937 ; Čepikova, 1935 ; etc.) suggests that *the individual shoots of perennial grasses themselves behave as spring or winter annuals and follow in their development the course established in phasic development.* These facts are in agreement with Lysenko's statements on annual plants. In the study of the biology of perennial plants, and, more particularly, of their facility to resume growth after repeated cutting or grazing, some discrimination must be made between the two large biological groups of perennial plants, namely,

Group 1 : Perennial plants with spring shoots ;
Group 2 : Perennial plants with winter shoots.

Observations on the resumption of growth of shoots as affected by the removal of different components (leaves, stem nodes and inflorescences) indicate that the decisive role in subsequent development and growth is played by the inflorescences and, before their formation, by the uppermost stem node. Undoubtedly, inasmuch as phenological phases in plants are an expression of their phasic development, it may be assumed that the elongation of the first internode is a *morphological indicator* of the completion of the first étape of phasic development in the shoot, that is, the completion of the stage of vernalization. The removal of the upper node cuts short the étape of phasic development acquired by the shoot. The period of stem elongation and emergence of inflorescence is the period of most vigorous increase in forage yield due to increase in stem formation.

The formation of aftermath by perennial grasses or the physiological ability of plants to develop after being cut or grazed at different phenological phases is closely connected with the storage of reserve substances in the plants. The significance of the nutrient reserve in the formation of aftermath is very great, as shown by Smelov (1937) and other investigators. Nevertheless the dynamics of reserve substances are closely connected with the following important factors :

(a) growth of plants in relation to the phasic development of the mother and daughter shoots (the periods of intensive consumption and of deposition of reserve substances in normally developing plants) ;

(b) the manner in which the grassland is utilized—the time of first cutting or grazing, frequency and height of cutting, date of final autumn cut, etc.

A discrimination must also be made on the sward between the aftermath of the first half of the summer (spring-summer growth) which is characterized by a considerable or prevailing participation of generative (mother) shoots endowed with rapid growth from the level of cutting, and the aftermath of the second half of the summer (summer-autumn growth) consisting almost exclusively of new daughter shoots. This discrimination must also be made because of possible differences in fodder value ; as the aftermath of the first half of the summer contains more stems, it would obviously be less nutritive than that consisting chiefly of leaves. In this respect, Evseev (1934) has produced some figures showing the greater fodder value of autumn aftermath of certain *Agropyron* species as compared with the stemmy spring-summer aftermath of the same species (Table 6.)

*Translation of Chapter 6 of paper by G. A. Tužihin, of the U.S.S.R. Fodder Research Institute, Lugovaja, Moscow Province, published in *Sovet. Bot.* 1939. No. 4. pp. 111-26.

Table 6.—Nutritive values of spring-summer and summer-autumn aftermath in dry steppes.

Type of aftermath	Date of sampling	Chemical composition in percentage of air-dry matter				
		Protein	Albumen	Fibre	Fat	Ash
Agropyron cristatum (*Eu-agropyron*)	May 29	13.62	10.63	27.56	3.12	5.51
	September 5	26.87	21.03	18.60	4.59	9.99
Agropyron repens	June 10	12.25	9.06	27.90	2.59	9.12
	September 15	20.31	17.31	21.00	5.05	8.77

Early and frequent cutting or grazing of plants interferes very considerably with normal development and growth in the mother summer shoots and the deposition in them of the reserve nutrients upon which the growth and development of the daughter shoots directly depend. The time, frequency and height of cutting of the autumn aftermath also determine the nature of wintering and the resumption of growth in the following spring.

The cutting of plants, particularly if it is repeated, before the deposition of reserve substances, or the retardation of the synthesis of plastic substances by frequent short cutting, may weaken the plants to a state of complete exhaustion, with the result that tillering and the developmental vigour of the whole plant are much reduced; resistance to unfavourable conditions is conspicuously less ; sensitiveness to drought and frost increases ; plants which have been impoverished in reserve substances cannot compete successfully with weeds or resist the attack of pests, and the sward becomes rapidly depleted and weedy (Klapp, 1937 ; Roberts and Hunt, 1936 ; Smelov, 1937).

As the production of reserve substances is one of the factors in the complex necessary for completing the first developmental phase in a shoot (the stage of vernalization), this is of especial importance in obtaining several full yields of hay in a season. It is obvious that this is governed by the rapidity of the completion of the first developmental phase in spring perennials (Table 7). Plants of special interest in connexion with the production of aftermath are *Lotus corniculatus*, double cut forms of *Trifolium pratense*, *Bromus inermis*, *Phleum pratense*, *Agropyron tenerum*, *Alopecurus pratensis*, etc. which produce stems rapidly, that is, plants which develop rapidly so that the individual shoots may be vernalized under variable spring-summer temperatures in a relatively short time. Several hay yields per season may be obtained from these plants by the use of appropriate measures to speed up shoot development, namely, fertilizer applications, irrigation etc.

Autumn perennials cannot give several hay yields in a season as their aftermath consists chiefly of leaves, although by earlier cutting in favourable seasons it may be possible to obtain a small second cut, particularly when tillering and earing in the aftermath of the mother shoots are reduced, that is, when it is possible to obtain a second cut at the expense of the spring-summer aftermath.

In addition to the use of plants which develop individual shoots rapidly, for example, *Lotus corniculatus*, red clover or *Bromus inermis*, for the production of good aftermath the presence of abundant foliage on the lower overground parts is also of great importance, as in white clover, *Festuca rubra*, *Poa pratensis* etc.

Table 7.—Observations on the aftermath after the first cut in the phase of flowering—seed filling.

Nos.	Plants	Date of the first mowing	The condition of the aftermath on August 28		
			Phenological phase	Average height of shoot (cm.)	
				Generative shoots	Vegetative shoots
1	*Trifolium repens*	4 July	Beginning of flowering, browning of heads	21	16
2	*Trifolium pratense*	4 ,,	Complete flowering, browning of heads	41	33
3	*Lotus corniculatus*	4 ,,	Complete flowering, formation of pods	44	38
4	*Festuca sulcata* ..	4 ,,	Tillering	—	10
5	*Agropyron tenerum*	15 ,,	Jointing—some earing	32	27
6	*Bromus inermis* ..	4 ,,	Jointing	—	38
7	*Poa pratensis* ..	4 ,,	Tillering	—	19
8	*Agrostis alba* ..	15 ,,	Beginning of heading	47	25
9	*Alopecurus pratensis*	4 ,,	Some earing	63	18
10	*Dactylis glomerata*	4 ,,	Tillering—some earing	55	32
11	*Festuca pratensis* ..	4 ,,	Tillering	—	19
12	*Festuca rubra* ..	4 ,,	Tillering	—	19
13	*Phleum pratense* ..	15 ,,	Beginning of jointing—some earing	43	20
14	*Lolium perenne* ..	4 ,,	Tillering—earing (beginning)	38	14

In the growth of daughter shoots (summer-autumn aftermath) aspects of considerable importance include the root system of the mother shoots as shown by Smelov (1937) and Evans (1927), and the amount of the mother shoots left after cutting, that is, the height of the stubble (Table 8). The vigour of growth of the daughter shoots depends entirely upon the height of cutting of the mother shoots.

An analysis of the first aftermath in timothy and ryegrass showed that when timothy plants were cut at a height of 1 to 5 cm., only the " bulbs" (haplocorm of the shoot) remained green ; when the plants were cut at 10 cm., an internode above the haplocorm also remained green and only the internode which was dissected during cutting dried up. In most cases the daughter shoots arose from the basal portion of the haplocorm. When cut at 1 to 5 cm. in the majority of cases, and particularly with cutting at 0 to 1 cm., only a single daughter shoot was formed on a haplocorm ; when cut at 10 cm. two or even three young daughter shoots were generally formed on a haplocorm.

Table 8. The effect of double cutting at a height of 0 to 1 cm., 5 cm. and 10 cm. on the vigour of aftermath formation. First cut at flowering phase.

Nos.	Plants	Height of aftermath growth (in cm.)		
		mowing at 0 to 1 cm.	mowing at 5 cm.	mowing at 10 cm.
1	*Trifolium pratense* (double cut)	12	21	24 (34-generative shoots)
2	*Lotus corniculatus*	18	24	26 (26-generative shoots)
3	*Medicago sativa*	14	18	24
4	*Festuca sulcata*	6	9	14
5	*Poa pratensis*	9	15	20
6	*Festuca rubra*	8	13	20
7	*Festuca pratensis*	8	14	18
8	*Phleum pratense*	9	17	19
9	*Lolium perenne*	9	12	17
10	*Bromus inermis*	12	21	28
11	*Agrostis alba*	11	17	21
12	*Dactylis glomerata*	12	21	27

The production of aftergrowth in ryegrass was due chiefly to new tillering (formation of daughter shoots), but in some cases growth was resumed on young shoots which had arisen from the first or, less frequently, the second nodes. The stubble dried as far as the node bearing a new shoot. With higher cutting the percentage of daughter shoots formed on overground nodes was increased. Thus after cutting at 0 to 1 cm. there was among 90 stems only a single case of the formation of a new shoot on an overground node (1.1 per cent) ; after cutting at 15 cm. there were only seven new shoots among 148 young shoots (4.7 per cent) ; and after cutting at 10 cm. ten new shoots were formed from among 150 shoots (6.7 per cent).

In order to strengthen the young daughter shoots it is necessary to devote particular attention and careful maintenance to ensuring that these daughter shoots make the fullest use of the reserve substances in the mother shoots ; here again the height of the previous cutting or grazing is of particular importance.

From Table 8 it may be seen that in all cases individual shoots were adversely affected by low cutting, but frequent and low cutting was less harmful to those plants with abundant leaves in the lowest overground layer. Because of their biological properties these plants are able to increase considerably their yield after it has suffered from intensive cutting. This can be confirmed by quoting some observations by Wiggans (1923) on *Poa pratensis* and *Dactylis glomerata* (Table 9).

With repeated cutting, tall grasses (*Phleum pratense*, *Dactylis glomerata*, French ryegrass) gave almost half the yield as compared with management for hay. *Agrostis alba* and *Festuca pratensis* gave about 75 per cent of their production under hay. *Poa pratensis* proved to be more productive under pasture management. In 1918 *Poa pratensis* and *Dactylis glomerata* were cut for hay and it was found that the yield

Table 9.—The yield of various plants repeatedly mown with imitation of grazing expressed in percentage of yield of plants mown for hay. From Wiggans' report.

Nos.	Plants	1914	1915	1916	1917	1918	Average for four years
1	*Phleum pratense*	45	50	33	35	—	40
2	*Agrostis alba*	63	125	47	70	—	76
3	*Festuca pratensis*	87	106	32	72	—	74
4	*Dactylis glomerata*	63	76	45	55	112*	60
5	*Poa pratensis*	160	131	83	78	128*	113
6	*Lolium perenne*	75	89	46	69	—	70
7	*Bromus inermis*	77	94	34	76	—	70
8	*Lolium multiflorum* (*italicum*) ..	71	—	—	—	—	—
9	French ryegrass	67	38	38	60	70*	51

*Under grazing.

of both grasses was higher under pasture management than under continuous hay management. In reporting this fact, Wiggans pointed out that the vitality of these grasses was not affected by frequent cutting in previous years.

It is quite evident that grasses with a vigorous growth of basal leaves would retain more viable shoots capable of subsequent growth, and, in addition, they are under intensive use most capable of competing with weeds.

In the experiment by Wiggans, *Dactylis glomerata* was surveyed in pure swards after four years of continuous simulation of pasture conditions; other grasses, not to mention the rapidly disappearing legumes, proved to be depressed chiefly by *Poa pratensis* and weeds.

In the study of the aftermath of perennial plants a fundamental analysis is required of the physiological processes which occur after the removal of the overground material. In each concrete case the aftermath is determined by a complex interaction of many factors, among which the chief appear to be the biological properties of the plants, the ecological environment and the type of economic utilization. If the knowledge of the possibility of regulating the factors determining the growth of aftermath is based upon a deep understanding of the nature of the restoration of cut or grazed swards, it will be possible to regulate aftermath formation on pastures in accordance with the demands of rural husbandry.

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THE PHYSIOLOGICAL BASES OF WINTER HARDINESS

Everyone interested in research on winter hardiness will undoubtedly have been impressed by the rapid increase in the experimental evidence recorded each year in the literature on this subject from all parts of the world. In the first edition (1935) of his rather incomplete and yet invaluable " annotated bibliography of the low temperature relations of plants", Harvey quoted some 3,412 references, and in less than a year added another 250 references in the appendix to the second edition (1936) which in fact represents only a fraction of what was actually published during that short interval.

Perhaps the most important of the many causes responsible for this rapid increase is that every year great losses are suffered, particularly in the northern countries of Europe and America, through damage amounting in some years to the complete destruction of autumn-sown plants during the winter-spring season. Another cause for this increasing interest in winter hardiness is the great perplexity of the problem which confronts us and which is becoming more clearly visualized in the light of recent and particularly Soviet researches, as well as the fluctuation in degree of winter hardiness such as was disclosed in the studies of Teuscher, who spent over 20 years in an attempt to discover, at least approximately, the relative winter hardiness in the plants being investigated.

The experimental evidence is, however, as extensive as it is full of contradictions and disagreements in which it is at times difficult to find the correct or, at least, the safer views. This study has been going on for more than a century, but has acquired little definite shape and most certainly needs critical revision and

systematization, if not co-ordination, before it can be utilized in science and practice. The need for brushing up and summarizing the present state of our knowledge in this very important field with a view to outlining, if possible, the main theoretical bases for further research in the physiology and inheritance of winter hardiness has been badly felt for some time, and more particularly during the past decade during which rapid advances have been made in the study of the biology of development. No such work has been attempted, although some of the component and related problems have been dealt with in more or less detail from time to time, for instance, by Molisch in 1897, Maximov in 1913, or Tumanov in 1930.

This gap in the world's literature has now been successfully filled by I. I. Tumanov's treatise on "The physiological bases of winter hardiness in cultivated plants" (Seljhozgiz, Leningrad, 366 pp. with 75 fig., 1940, R.7.50 in cloth cover). This monograph is the more welcome as it has been prepared by an author whose name is associated with many recent advances made in this field. Another important point is that the author was in a position to make the fullest possible use of Soviet scientific literature where most important advances in the study of winter hardiness have been recorded, while in addition he also had access to many investigations then unpublished. It is regrettable that in its present shape the monograph is still available to only a relatively small circle of investigators outside the Soviet Union, for whom indeed it was primarily intended. It is for this reason that in preparing this review it was decided to give an account not so much of the relative merits and faults of the monograph as of the more important features of which little is known outside Russian-reading circles.

It must first be noted that Tumanov's book is not an extensive review of the literature, but of the present state of knowledge with special reference to physiology and less to the inheritance of winter hardiness, particularly frost resistance, in plants. This inevitably introduces a personal element in the appreciation and selection of the researches mentioned, as well as in the emphasis and arrangement of the material available, but this we understand was the task set for the author.

In order successfully to protect a plant from adverse winter conditions, we must know as fully as possible the relations of the plant to the seasonal element of winter. The external environment exerts, on the one hand, an adverse effect which may damage or even kill the plant, and, on the other hand, a beneficial action which increases resistance to the harmful action of winter conditions. Agronomical arrangements are intended to facilitate the beneficial action and thereby to decrease or even eliminate the harmful action. No matter how successful agronomical methods may be in helping a plant to overcome the adverse action of winter, the wintering of a plant is, as it were, a balance struck between harmful and useful actions, that is, in the third place we must know how to measure and utilize this balance.

It was on this basis that the book under review was planned and the material available to the author was arranged; it cannot be said that the arrangement is quite faultless; for example, it would appear that the second part should include a discussion of pre-sowing hardening of germinated seeds, which is referred to only very briefly in the third part.

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A brief introduction dealing with the significance of the problem of winter hardiness of agricultural plants and the extent of the destruction during autumn, winter and spring (pp. 5-11) is followed by the first part of the book proper (pp. 12-123), which is devoted to the harmful processes which injure and kill plants during the cold season. The harmful actions exerted on the plants during this period interfere in various ways with the normal course of the most varied physiological functions, but the author found it possible to group these in seven chapters. In the

first chapter on the freezing of plants, the author considers the direct action of low temperatures on the plant body, the dehydration of the plant as a result of ice formation and, connected therewith, the increasing concentrations of cellular sap, mechanical pressure of ice in frozen plants, as well as the effect of the rapidity and duration of freezing and thawing. This chapter concludes with a review of the character of the damage caused during freezing and the agronomical methods intended to reduce the harmful effects of freezing ; the latter are in general based upon the regulation of temperature and the water environment in which the plants are growing.

The second chapter deals with the destruction of plants under an ice crust ; although the most recent investigations have refuted the commonly accepted view that plants perish because of a lack of oxygen, these new investigations so far fail to give any definite diagnosis. In the third chapter the author considers the heaving of seeds and plantules which results in a considerably reduced tillering, and in the fourth chapter, the exhaustion of plants under a deep snow cover, which appears to be a very complex action on the fundamental physiological function of the carbohydrate environment within the plant, with the result that plants are weakened and are liable to attacks of "snow mould". Chapters on the soaking of plants (5), the depletion of plants as a result of winter-spring drought (6), and their destruction at temperatures slightly above freezing point (7), the nature of which is still to be studied, conclude Part 1 of the book.

Summing up this section it may be concluded that the main harmful actions occurring in wintering plants are as follows :

(1) The pressure of ice on considerably dehydrated cells (freezing and destruction under an ice crust).
(2) Starvation of plants (exhaustion).
(3) Drying (winter dehydration and moisture deficiency during spring drought in plants damaged or heaved during winter).
(4) Damage and destruction due to lack of oxygen (soaking of germinated seeds and injured plants).
(5) Interference with normal metabolism associated with disintegration processes prevailing over synthetic processes (destruction of certain plants at temperatures slightly above freezing point).

The majority of harmful processes act very slowly and a considerable time is usually necessary for them to acquire a lethal effect. Perhaps only freezing sets in very rapidly, but in the open even this process is very slow, particularly in its effect on such important organs as the tillering node. Investigations of wintering of plants are complicated by the fact that during the cold season different sequences and combinations of harmful actions occur, for instance, frost-injured plants may later suffer from soaking or on the contrary from drying ; excess of moisture may be combined with ice formation, heaving with drying, or exposure, etc.

* * * * *

The second part of the book (pp. 124-242) is devoted to an examination of the useful processes fostering the safe wintering of plants, that is, in the first place, of those physiological processes which create an internal environment which protects plants from adverse winter conditions. It has been known since the second half of the last century that a high frost resistance is not a property which is always inherent to a growing plant. Neither cessation of growth nor the suppression of activities in cells, as has been repeatedly demonstrated, are yet adequate to bring about a high frost resistance. In order to develop such a quality the plants must undergo within themselves, as noted by Göppert in 1830, certain internal readjustments. These processes, which are known under the general name of hardening,

are not yet fully understood, although recent advances made in this field have enriched our knowledge of them.

In many Soviet investigations, chiefly associated with Tumanov, it has been found possible to establish two ecologically and physiologically distinct phases in the hardening of plants and, in their main outlines, the factors concerned therein, with the result that, in hardening under laboratory conditions, plants may now attain as high a frost resistance as they would in the open. This discrimination in the complex process of hardening is a distinctive feature of Soviet research. Considerable advances in this field have also been made elsewhere, but in their coordination one must remember that, in the Western European and American research, by hardening is understood only the first of these two phases. As the second phase has been dealt with in only a few investigations and as in almost all investigations the relations between these phases of hardening have remained obscure, we shall describe below the general features of these phases.

The investigations of Tumanov (1935) and his associates show that the first phase of hardening is acquired by winter plants (chiefly cereals) at 0 to 6°C. in light; apparently, the upper temperature limit is determined by temperatures at which growth becomes more or less pronounced. Under these conditions, plants rapidly accumulate large amounts of sugars (up to 30 per cent). It would appear (Tumanov, 1931) that hardening would be possible at alternating temperatures, 10 to 15°C. during the day, and in the vicinity of freezing point during the night. During the hours of day, assimilates will be rapidly manufactured and stored, while low night temperatures will arrest the growth of the plants. Under these conditions, however, the plants exhibited a conspicuous reduction in their ability to acquire the second phase of hardening, probably because of too rapid growth during the daylight hours. The frost resistance acquired during the first phase of hardening is not generally very high, the lethal temperatures for wheat varying from—7 or —8°C. to —10 or —12°C. The rapidity of acquiring this first phase of hardening depends largely upon the environment; under laboratory conditions it may be fully acquired in 5 days or less.

The second phase of hardening is acquired only under much lower temperatures, about —2 to —5°C., and is evidently based upon different physiological processes. Under these conditions, owing to the freezing of water in the tissues, the process of dehydration occurs, and thus, at least as far as water relations are concerned, this phase of hardening is similar in its effects to intensive wilting. The second phase progresses more rapidly, although excessive moisture in the plant's environment may retard it considerably. The frost resistance is conspicuously increased as a result of the second phase of hardening, for instance, in wheat, Lutescens 1060/10, the percentage of survival was increased from 17 at —13°C. after the first phase of hardening to 96 at —17°C. after the second phase. Since the second phase may begin and proceed only when and if the first phase has been completed, it is obvious that dehydration of tissues and low temperatures may become effective only in the presence of the protective substances and, as we shall see later, while the plant is in a certain physiological state, or more precisely, at a definite developmental phase.

The hardening of woody plants is somewhat different, as the accumulation of starch usually begins in them in the second half of summer when their growth is much reduced. On converting starch into protective substances during the autumn, woody plants also enter the second phase of hardening at still lower temperatures. The existence of the second phase has, however, been demonstrated so far in experiments with plants which form sugars, and it still remains to be seen whether the second phase of hardening is required at all by woody plants in which oils and not sugars are the protective substances.

Going somewhat ahead of the text, we may note yet another advance made in hardening of plants, namely, the pre-sowing hardening and test of slightly germinated seeds as shown by Timofeeva (1935) and Saltykovskiĭ (1935) and mentioned briefly in the third chapter.

In Saltykovskiĭ's experiments, germinated seeds after the first phase of hardening, evidently at the expense of starch in the endosperm, showed good resistance to a temperature of —12°C. The second phase depends upon certain properties of the protoplasm, and in this respect slightly germinated seeds differ but little from green plants, providing, of course, that they are at the same developmental phase. Tumanov is undoubtedly correct in stating that " during the period of growth green plants may be subject to certain effects and changes which may be absent in the testing of germinated seeds", but in our opinion this fact indicates both the disadvantage and advantage of pre-sowing hardening, which, with further perfection in technique, will undoubtedly acquire outstanding importance both in practice and in the understanding of the state of seeds sown in the autumn. The fact that it is possible to harden (the first phase) germinated seeds has also been shown by Suneson and Peltier (1934) and Peltier and Kiesselbach (1934).

We must refrain from examining the physiological and biochemical processes which occur in plants subjected to low temperatures, to which many new investigations have been devoted and which are examined in the fifth, sixth and particularly the seventh chapters. We may note, however, that the results so far obtained have failed to disclose the nature of hardening, although it has been successfully studied in many investigations ; the connexion between frost resistance and sugar content is still maintained, but this feature has proved to be much more complicated than was thought in early investigations, where a direct correlation between some properties and frost resistance was sought.

As regards dehydration (which naturally increases the relative sugar content) and the amount of ice formation in frozen plants, which are examined in chapter six, one has to admit that " wintering is determined not only by the magnitude of the adverse action, that is, by the amount of ice or more precisely by the magnitude of the pressure and the degree of dehydration, but also by the differences in the abilities of cells to withstand this adverse effect . . . . . and a high frost resistance is attained not merely by reducing the adverse action, but also by increasing during hardening the resistance of the protoplasm to mechanical action".

Finally, it is worth mentioning that, as other investigations have shown (Timofeeva, 1935), hardening to frost increases resistance to other unfavourable influences experienced during wintering, such as the ice crust, soaking, etc., that is, hardening increases what may be described as the general winter hardiness of plants.

We shall proceed now to the eighth chapter of the second part where the author discusses the significance of the period of dormancy in woody plants and of the developmental phases in cereals for their winter hardiness. Here the author presents the results of investigations (mostly unpublished when the book was being prepared) of which little is yet known outside U.S.S.R., and which form not only another distinct feature of Soviet research, but also give an entirely new direction and approach to the study of winter hardiness, namely, in relation to phasic development. As this section is of the utmost importance for further research, we shall dwell upon these new aspects, but, of course, in so far as they are revealed in the monograph under review.

In the research of Vasiljev (1934), Kuperman (1935), Timofeeva (1935), Kuperman and Zadoncev (1936), Saltykovskiĭ and Saprygina (1935) and many other Soviet investigators, frost resistance has proved to be unmistakably connected with phasic development. In all these experiments, chiefly with winter cereals, frost

resistance was lower and at times conspicuously so in plants from vernalized seeds, that is, from seeds with embryos which as far as could be ascertained had completed the thermo-phase. For instance, in Tumanov's investigations (1935), the percentage of surviving wheat plants was as follows :

	Vernalized	Unvernalized
Ukrainka : early sowing	16	92
,, late sowing	12	94
Moskov. 02411 : early sowing	7	93
,, ,, late sowing	0	96

Again in the experiments of Tumanov and Ivanova (1935), vernalized plants of Lutescens 0329 in both early and late sowings became depleted at higher temperatures (—11 to —12°C.) than plants from unvernalized seeds, and, on the whole, the frost resistance was higher when the duration of the preceding vernalization had been shortened. Nevertheless, even after 20 days of vernalization of winter wheats and 15 days of vernalization of winter rye, their frost resistance was conspicuously lowered. Special investigations conducted in the Leningrad region showed to what risks autumn sowings are exposed in regions where the early autumn temperatures favour the vernalization of sown seeds. Thus, when Lutescens 0329, Moskov. 02411 and Minhardy were sown by the end of August they completed their thermo-phase in the 1934-35 season on about January 13, in the 1935-36 season, on January 1, and in the 1936-37 season still earlier, namely, Lutescens 0329 (partly) and Moskov. 02411 (fully) were vernalized by November 19.

Such a variation in the time of completion of the thermo-phase cannot be attributed to the variation in the climatic conditions alone. As shown by Kostjučenko and Zarubaĭlo (1935), a partial or even complete vernalization of the thermo-phase is quite possible, particularly under the conditions characteristic of the latter part of the cold northern summers. Furthermore, the partial vernalization of seeds may also be possible during prolonged drying in the open in a cold and rainy season, as the seeds may be sufficiently imbibed to begin slow growth. Evidently, the longer the seeds are vernalized before sowing (during ripening or drying), the more rapidly and earlier will they complete vernalization of the thermo-phase after being germinated or sown.

There are two possibilities in the after-sowing vernalization in the open : (1) the seeds may be completely vernalized in the period before the beginning of winter, (2) the vernalization of the thermo-phase may be completed either by the beginning of winter or during the winter (see below).

In the first case, more particularly when the plants have had an opportunity to grow for a lengthy period of time, they would, as will be shown below, lose their ability to harden, with the result that their resistance to frost will be much reduced. There is a divergence of views upon this point. Some investigators (Kuperman and his associates) maintain that frost resistance begins to fall in vernalized plants with the beginning of the photo-phase. Actually, in some investigations, resistance to frost fell rapidly when the plants were grown after vernalization of the thermo-phase under conditions favouring the development of the photo-phase (high temperatures and long day). On the other hand, however, a fall in frost resistance was also noted when vernalized plants were grown under conditions not favourable for the development of the photo-phase, as may be the case with late autumn sowings of vernalized seeds.

At this point, Tumanov refers to his own investigations in 1936-37. When plants were tested on November 2, vernalization of the thermo-phase having been fully completed by November 19, frost resistance was reasonably high, the per-

centage of survival in Lutescens 0329 at —12 to —18°C. varying from 98 to 84; when the plants were tested on December 14, that is, 25 days after vernalization, frost resistance had fallen, the percentage survival varying from 85 to 27 at temperatures of —13 to —22°C. Before the tests, all plants were kept under conditions which would ensure their hardening. In these investigations the loss of the ability to harden was observed only when plants grew for some time after the completion of the thermo-phase, as was the case with winter rye Vjatka, the percentage survival of which varied from 78 to 44 in the first test, and was only 25 at —13°C. in the second test, while no plant survived temperatures less than —15°C.

The situation is different in the second case, that is, when vernalization of the thermo-phase is completed so late that no growth is possible before the plants are frozen. In Tumanov's investigations in 1935-36, when vernalization was completed by January 1 in winter wheats and by December 1 in winter rye, the percentage survival at —14 to —18°C. varied from 96 to 74 in Lutescens and from 81 to 70 in Vjatka. Similar features were observed in another experiment where the percentage survival was much higher after later sowings.

It is worthy of special notice that, as Oleĭnikova showed, under the relatively mild winter conditions of the Leningrad region the thermo-phase can be vernalized in sown seeds during the winter under the snow cover. In this investigation, winter wheats were sown on November 17, January 1, February 1 and March 1 and 31 in the open, and as from the beginning of April were transferred to greenhouses under temperatures which prevented the completion of the vernalization of the thermo-phase in those plants which had failed to complete this phase in the open. Winter rye, Vjatka, failed to ear only after the last date of sowing, and winter wheats after the last two dates of sowing; therefore, even in strong winter plants, at least in some years, the thermo-phase may be fully or partially vernalized during the winter.

The completion of the thermo-phase alone, Tumanov considers, does not yet reduce, at least to any considerable degree, the frost resistance of plants when conditions for growth are absent. It is different under a deep snow cover or during a temporary thaw; plants may resume their growth very readily and would thus lose or show a reduced frost resistance. It would therefore appear that after vernalization of the thermo-phase, the growing point is capable during resumption of growth of changing the state of the protoplasm in all other tissues; possibly a hormonal mechanism may be the explanation.

Although Kuperman (1935) and others produced reasonably convincing evidence that vernalized plants accumulated much smaller quantities of sugars than unvernalized plants, yet in the investigations of Tumanov and Fedorova (unpublished) the amount of sugars in vernalized plants (which first rose very slowly, but later, in April, more or less rapidly) was about 26 per cent on May 7, that is 10 per cent lower than in unvernalized plants, and about the same as in unvernalized plants before wintering. That is, vernalized plants have sufficient amounts of sugars and a sugar deficiency cannot be regarded as the cause of their lower frost resistance.

In the investigations of Tumanov and Ivanova (unpublished), the exposure of vernalized plants to the conditions prescribed for the second phase of hardening was of no avail, although it is during this phase that the plants should show a considerable increase in their frost resistance. It may thus be assumed that those changes which originate during vernalization of the thermo-phase readjust the protoplasm in such a way that it loses the ability to undergo appropriate changes during the second phase of hardening, regardless of the presence of protective substances, dehydration and low temperatures. This is more likely since no abrupt fall in frost resistance was observed after the vernalization of previously hardened seeds.

It is of great interest in this connexion to compare frost resistance with the length of the thermo-phase. It is known that the latter varies within winter wheats from 18 to 57 days or more ; in certain Scandinavian varieties, according to Beljdenkova, it was found to be longer than 75 days and yet these wheats proved to be only slightly winter hardy in Šmelev's tests. Certain varieties which have a thermo-phase of similar length, for instance, Nebraska 60, Kooperatorka and Argentine 38 M A, or Kanred and Erythrospermum 714, differ conspicuously in frost resistance. Again, winter rye has a relatively short thermo-phase and yet is much superior to many winter wheats in frost resistance. Therefore, further investigations fail to confirm the existence of a parallelism between the length of the thermo-phase and frost resistance, as first announced by Buĭlina (1935), and they suggest rather that these characters have different physiological bases.

This does not mean, however, that the length of the thermo-phase is of little or no importance, for it is obvious that the longer this developmental phase, the longer duration of vernalization is necessary after autumn sowing, and thus the less is the risk of growth after the thermo-phase has been completed. Further investigations will certainly be required before any generalization can be made on this point, particularly in view of certain claims (Šestakov, 1936) that some wheat × rye hybrids may retain a relatively high frost resistance when sown after vernalization and grown in continuous day. [It may be noted at this point that in studying the length of the thermo-phase in various plants, little or no attention has been given to the conditions under which the seed ripened ; partial vernalization, particularly when ripening takes place late in the season, may lead to a "reduction" in the length of the thermo-phase, if this is measured from seed germination.—M.A.O.]

In this connexion the seeding date becomes of rather unexpected importance and requires revision. So far no definite conclusions may be drawn on this point, as the question has proved to be much more complicated than was previously apparent, even when considered in connexion with phasic development. In Šmelev's investigations with twenty-six winter wheats (1936-37), the percentage survival after sowing on September 5 was on the average twice as high as after sowing in August, when the plants were tested on January 10 at —15 to —16°C. It should be mentioned that in this investigation the difference between lots sown on different dates was negligible at the first test of frost resistance on November 5 before the thermo-phase had been completed. On the other hand, according to reports of 1931-32, in the southern parts of the Ukraine, September sowings showed the best wintering, although October sowings wintered better than August sowings. In 1933-34 in the same region, better wintering was observed after early sowings (August-September) than after late sowings (September-October). Apparently the effect of later sowing is not confined merely to the conditions of the thermo-phase. Moreover, it was recently shown that late sowings were inferior in size of yield.

The old question of obtaining spring (early) varieties with a high winter hardiness now appears in quite a different light. It may be remembered that as early as 1927 Hayes and Aamodt claimed that spring (early) hybrids between Marquis and Minhardy wheats were quite distinct in their relative winter hardiness ; it was then claimed that by "the recombination of genetic factors for cold resistance and for habit of growth . . . . . it is possible to obtain spring varieties which are as winter hardy as the most winter-resistant varieties". More than a decade has elapsed since these claims were put forward and "a close correlation between growth habit and cold resistance, although the linkage was not absolute" proved to be of no avail.

[Reference may again be made at this point to the view expressed by McKinney (1940) that "a knowledge of growth phase and character expression in relation to environmental factors will facilitate the adequate planning of many genetical studies

and the interpretation of the results," that is, genetical studies and hence hybridology must be based upon the principles of the theory of phasic development.—M.A.O.]

As in many other fields, this theory has revealed in this particular branch of research a very considerable complication of the issues thought previously to be quite simple. For instance, recent studies in hardening of plants have shown that frost resistance increases greatly during the second phase of hardening. In the presence of protective substances, dehydration and low temperatures, the protoplasm becomes readjusted with the result that its resistance to mechanical pressure is much increased. For this purpose, however, in addition to the environmental factors, a certain physiological capacity of the protoplasm to change in the required manner is indispensable, and this ability may be fully or partially lost under the influence of the external and internal factors which may affect the state of the protoplasm. In particular, this ability is lost during growth in plants which have completed the thermo-phase and in woody plants after the break in winter dormancy.

Hardening of plants is a reversible process and evidently the loss of hardening may be traced to a resumption of growth ; the second phase of hardening is particularly easily lost when the thaw begins. However, if temperatures during the thaw are not too high and the plants retain the first phase of hardening, they may, given favourable conditions, regain the second phase.

It is not possible to review the remainder of this part of the book in detail. The second part concludes with considerations of methods of increasing and maintaining the acquired winter hardiness with particular reference to the effects of fertilizers, time of cutting grassland plants, length of day and other seasonal climatic factors. The bases of building up resistant forms by hybridization are also briefly considered. It must be noted that the theoretical bases for obtaining resistant hybrids from non-resistant or winter and spring parents are at the present time too vague. No reference is made to Lysenko's methods of " training of plants " and related claims either here or elsewhere. Intravarietal crossing appears also to increase winter hardiness. The final chapter of this section deals with regeneration of plants and the maintenance of plants damaged during the winter.

* * * * *

The third part of the book (pp. 243-333) is devoted to an examination of the plant as a balance between harmful and useful processes in various crops (the winter hardiness of species and varieties). The first chapter of this part is devoted to methods of evaluating winter hardiness in plants and diagnosing their condition during the winter, in which the author returns once more to vernalization, but this time as a " provocation method " recommended by Lysenko (1935) and Maksimčuk (1935) for a field test of winter hardiness in regions with a mild or short winter. The author considers here in some detail other, chiefly Soviet, methods of testing winter hardiness, including the so-called " bundle " method adopted in his Laboratory in the USSR. Institute of Plant Industry. American and Soviet equipments for freezing plants under laboratory and field conditions are also briefly described.

On the whole, despite many shortcomings and the clumsiness of the field (direct) test, the field methods are gaining or rather regaining ground. The indirect methods which are, on the whole, based upon properties perhaps concomitant and connected with, but which do not determine winter hardiness are less reliable and may at best demonstrate only the degree of success in acquiring the first phase of hardening. The indirect methods, invariably linked with killing of plants, are even less suitable for breeding purposes and, with the exception of a few, chiefly American investigations, are not used for testing winter hardiness, although they have retained their place as analytical methods which make it possible to reveal the nature and type of winter hardiness. The subsequent three chapters deal with winter hardiness of winter crops and perennial forage plants (pp. 264-86), the winter hardiness of fruit

and sub-tropical crops (pp. 286-317) and the resistance of spring crops to frost (pp. 318-29). The final chapter deals with frost resistance of weeds and plant parasites (pp. 330-2), and this part in common with the other two is followed by brief conclusions.

* * * * *

The monograph is concluded with a list of literature quoted in the text (pp. 334-55), an author index (pp. 356-60), a subject index (pp. 361-4) and finally, in common with all Soviet-published books, with the contents (pp. 365-6).

Unfortunately, owing to lack of space, the author was unable to give a more complete bibliography on winter hardiness and his list had to be confined to 588 (262 Soviet) references, mostly of recent date, of which 345 (224 Soviet) are not found in the second edition of Harvey's annotated bibliography. For many of the incomplete or incorrect references which are a frequent occurrence among the Soviet references in the annotated bibliography, full bibliographical data are given, although neither is Tumanov's list faultless in this respect; on too many occasions does the author refer to the paging of separates or unusual abbreviations, and there are too many misprints.

Nevertheless, despite its shortcomings and brevity, the list of references given in Tumanov's book is another appreciable contribution to the literature on the subject, particularly if we add a list of 252 (113 Soviet) references quoted by him in a review of the literature on winter hardiness for 1934-35 (*Vestnik selfskohoz. Lit.* No. 8-10.1937) the greater part of which is not found either in Tumanov's newer list or in Harvey's bibliography. It must be noted that the publication of Tumanov's manuscript, which was completed by the end of 1937, was very considerably delayed and apparently no opportunity was given to bring the matter more up to date. Thus by the beginning of 1938 the literature pertaining to winter hardiness in plants exceeded 4,300 references according to these undoubtedly incomplete records.

In conclusion it may again be noted that Tumanov's work describes the state of the subject up to the end of 1937 and that the three years since that date have been marked by rapid advances in our knowledge of plant life and its relations to the environment; new questions have arisen and many older ones require to be revised. It may be hoped, therefore, that the second edition of this monograph may soon follow and will include information from more recent investigations in this field of biological research, but this time without such a delay in publication.—M.A.O.

COMMEMORATION OF "ORIGIN OF SPECIES" IN U.S.S.R.

The 80 years which have elapsed since the day of publication (November 24, 1859) of the first edition of Charles Darwin's "The origin of species by means of natural selection or the preservation of favoured races in the struggle for life" have been celebrated in U.S.S.R. at special sessions of the Academy of Science in Moscow and Kiev, in special seminars and reports at scientific centres as well as by the Soviet agro-biological press throughout 1939.

The plenary session on Darwin at the Academy of Science in U.S.S.R. was opened by an address by V. L. Komarov, the president of the Academy, on November 27, 1939, in the Conference Hall of the Academy at 14, Volhonka, Moscow. The president's address was followed by three reports, namely,

Acad. B. A. Keller: 80 years of "The origin of species."

Acad. M. B. Mitin: Darwinism and Marxism.

Acad. E. M. Jaroslavskiĭ: Darwinism and atheism.

On the following two days, five more reports were read at the plenary meetings of the Biological Section :

Acad. N. I. Vavilov : The origin of cultivated plants.
Acad. T. D. Lysenko : Darwinism and agro-biological science.
Acad. I. I. Schmalhausen : The motive factors of evolution.
Prof. I. M. Poljakov : The modern anti-Darwinism.
Prof. Ju. Ju. Schaxel : Darwinism and vitalism.

It may be noted that Charles Darwin was elected as a corresponding member of the Imperial Academy of Science, St. Petersburg, in December, 1867, when the following diploma was issued to him.

Imperialis Academia Scientiarum Petropolitana virum illustrissimum
CAROLUM DARWIN LONDINENSEM
sagacissimum rerum naturalium perscrutatorem socium ab epistolarum commercio in sectione biologica rite elegit electumque literis his publicis renunciavit die XXIX mensis decembris anni MDCCCLXVII.

It is of interest to note that in this diploma " sagacissimus " was used in place of " doctissimus " or " eruditissimus " which were then used commonly in the diplomas issued by the Academy.

A special session on Darwin was also held at the Academy of Science of Ukrainian S.S.R. at Kiev in November, 1939 ; among the numerous reports presented, the following have been published in *Visti Akad. Nauk URSR.* Nos. 9/10. 1939.

Acad I. I. Schmalhausen :	Motive factors of evolution (pp. 27-40).
Acad. N. G. Cholodny :	" The origin of species " and Darwin's researches in physiology of plants (pp. 41-51).
Prof. M. Scharleman :	The fundamental zoo-geographical conceptions of Charles Darwin in relation to the fauna of Ukraine (pp. 52-9).
I. G. Pidoplička :	Geological researches of Charles Darwin and their significance for geologists and botanists.

No other particulars regarding the Darwin session in Kiev have been published. In October, 1939, 130 years from the birthday of Charles Darwin were also marked by a special session at the Ukrainian Academy of Science in Kiev (*Visti Akad. Nauk U.R.S.R.* Nos. 3/4. p. 102. 1939).

Special seminars connected with the celebration of 80 years of " The origin of species " were opened at the Botanical Research Institute of the Academy of Science in U.S.S.R., Leningrad (*Priroda*, 1939. No. 11. p. 121). The plan of these seminars included the following items :

1. Criticism of anti-Darwinism theories and individual works.
2. Studies in species formation, cycles of development and evolution of lower plants.
3. The fundamental laws in the struggle for existence in vegetation.
4. History of flora and vegetation of U.S.S.R.
5. Phylogeny of plants.

In a further attempt to promote a better knowledge of Darwinism, a series of lectures were planned to cover the following items :

1. Darwinism and phytocoenology.
2. Darwin and the problems of systematics.
3. Darwin and phytogeography.
4. " The origin of species " and methods of plant systematics.
5. The problem of species in the light of Darwinism.
6. Evolution of photosynthesis.

These seminars will be continued during 1940, when the following reports will be read :

B. N. Gorodkov : Is there a relation between the vegetation of steppes and tundra ?
A. P. Iljinskiĭ : Darwin's researches on different forms of flowers in the plants of the same species.
L. F. Pravdin : Darwin's research on cross-pollination.
T. M. Zarudnaja : Vegetative hybridization in the light of research of Acad. Lysenko and his school.
V. A. Brilliant : Timirjazev's researches on photosynthesis.
B. K. Šiškin and D. E. Janiševskiĭ : Anti-Darwinism in modern plant morphology.
N. F. Komarov : Modern status of experimental study of natural selection.

Some of the results of the Darwin seminar have been published in *Sovet. Bot.* 1939. Nos. 6-7, a double issue dedicated to " the memory of the greatest biologist, Charles Darwin, on the noteworthy day of 80 years since the publication of ' The origin of species ' ". The papers in this session included the following :

V. I. Poljanskiĭ : 80 years of " The origin of species " (pp. 5-11).
S. V. Juzepčuk : The problem of species in the light of Darwin's doctrine (pp. 12-34).
A. P. Iljinskiĭ : Darwin and phytogeography (pp. 35-40).
A. A. Elenkin : Insolvency of " laws " of mobile equilibrium and of theory of equivalentogenesis (pp. 113-28).
I. V. Palibin : Heribert Nilsson in the struggle with Darwinism (pp. 129-38).
R. Zinger : On anti-Darwinism tendencies in modern systematics of higher basidial mushrooms (pp. 139-44).
V. I. Poljanskiĭ : Concerning an attempt to " refute " Darwinism in modern systematics (An account of " dynamic system " of Bunzo Hayata) (pp. 145-54).
P. A. Černomaz : On the prospects of developing Darwin's doctrine in U.S.S.R. on the basis of socialistic forms of rural husbandry (pp. 199-205).

The November issue of *Priroda*, journal of the Academy of Science in U.S.S.R., was also devoted to celebrating these 80 years, and included the following sixteen articles in addition to various annotations :

Acad. B. A. Keller : Darwin and Soviet Darwinists (pp. 7-12).
Acad. I. I. Schmalhausen : The motive factors of evolution (pp. 13-25).
M. M. Kamšilov : Natural selection as a creative factor of evolution (pp. 26-34).
G. A. Schmidt : Charles Darwin's doctrines on indirect selection in relation to his concepts as to the significance of correlations (pp. 35-41).
G. A. Mastaler : Darwin and genetics (pp. 42-50).
E. N. Sinskaja : What is a centre of species origin in the light of Charles Darwin's doctrine ? (pp. 51-8.)
L. V. Krušinskiĭ : Biogenetic law in the light of experimental biology (pp. 59-65).
A. N. Juzefovič : Interruptions in gradualness in evolution of man (pp. 66-74).
N. I. Tarasov : Darwin's monograph of Cirripedia and " The origin of species " (pp. 75-7).
K. K. Serebrjakov : " The origin of species " and Darwin's botanical researches (pp. 77-82).
A. P. Iljinskiĭ : Under-estimation of Darwin's researches (pp. 82-7).
V. I. Poljanskiĭ : Anti-Darwinism in the country of Darwin (pp. 87-96).
N. Davidenkov : Erasmus Darwin (pp. 97-103).
K. K. Serebrjakov : Scientific friends and associates of Darwin (pp. 106-13).

K. Ja. Ratner and K. I. Šafranovskiĭ: First translations of Darwin's works into Russian (100 years since the Russian translation of one of the earliest Darwin works and 70 years since the first Russian translation of "The origin of species") (pp. 114-6).

G. A. Knjazev: Election of Charles Darwin as a corresponding member of the St. Petersburg Academy of Science (according to material of Archives of Academy of Science in U.S.S.R.) (pp. 117-20).

Jarovizacija, a journal of the biology of development, edited by T. D. Lysenko and I. I. Present, also devotes some space to these celebrations. Issue 5/6 (26/27) 1939, contains a special section which includes, in addition to a Russian translation of Darwin's article "on the sexual relations of three forms of *Lythrum Salicaria* (*J. Linn. Soc. Bot.* Vol. 8. 1865, pp. 169-96), and of Francis Darwin's introduction to the German edition (1911) of "The origin of species", Present's article on "the revolution in science created by Charles Darwin" (pp. 47-70), Acad. N. V. Cicin on "Darwinism and distant hybridization" (pp. 71-82), where much space is devoted to discussions of his more recent intergeneric hybridization, chiefly between yellow *Acacia* and herbaceous legumes (*Pisum, Lens, Lupinus, Melilotus*, etc.). Another article in this issue is that by Acad. E. F. Liskun on "the race and fodder" (pp. 83-92). Articles on Darwin, Darwinism and related subjects are, however, a common feature of this journal. Special articles on 80 years of "The origin of species" appeared also in many other Soviet agricultural, botanical and biological journals in 1939.—M.A.O.

INTERNATIONAL LUCERNE TEST, HUNGARY

[Reviewer: G. M. Roseveare]

In *Kisérletügyi Közlemények*. 42. 177-87. 1939, Dr. Árpád Szücs presents a report on the last two (final) years' results of the International Lucerne Test as carried out at the Royal Hungarian Experiment Station for Plant Industry, Szeged, Hungary, under the direction of Dr. E. Obermayer. The Test was organized in 1933 by the Imperial Bureau of Pastures and Forage Crops, Aberystwyth (see Whyte, R. O. *Herb. Rev.* 1. 125-31. 1933). Fourteen varieties of lucerne from all parts of the world have been under observation for six years, and exhibit the following characteristics under conditions at Szeged.

The seven Hungarian varieties, representing the northern European type, are in general erect, of rapid growth, have good sprouting ability and are resistant to drought. They flower earlier and can therefore be cut more often than the other varieties tested. Bucsatelep, Nagyszénás and Pernyés-puszta exhibit the best sprouting. F.104 was distinguished by the earliest seed-ripening and also the best ratio of leaf to stem.

Provence, from the south of France, is erect and of good tillering capacity, but gives relatively poor yields both of forage and seed.

Grimm is inclined to prostrate habit, lacks vigour, and gives a poor yield of fodder. The seeds ripen early, but seed yield is poor. It produces many short stems with small leaves.

The five Asiatic varieties tested all grow more slowly than the Hungarian varieties and have thicker stems. The yield of seed is good, but the seed takes a long time to ripen. (a) Khivian is a prostrate type, lacking in vigour and sprouting

ability. The ratio of leaf to stem is good, and the type produces numerous stems bearing short, broad leaves. (b) Semiryechensk is fairly erect in habit, its yield of forage is exceptionally good and its seed yield the best of all the varieties tested. The stems are very long and thick, and the ratio of leaf to stem is unfavourable. (c) Turkmen is quite erect, has good sprouting ability and gives a very good yield of forage. Of the five Asiatic varieties, Turkmen flowers and ripens earliest. (d) Middle Turkestan is also an erect type and gives a fairly good yield of forage. It is slow in growing and late in ripening, but gives a good seed yield. The stems are long and thick, and the ratio of leaf to stem is unfavourable. (e) Asia Minor is less erect. The forage yield is low, the leaves are large, the ratio of leaf to stem is poor, but the percentage of air-dry hay is high. This is a late variety, producing a good quantity of fine seed.

SCANDINAVIAN LITERATURE

DEVELOPMENT OF FOOD UNIT CALCULATION

[Reviewer: R. PETER JONES]

In a discussion of the continued development of the food unit calculation in Scandinavian countries, N. Hanson states (*Nord. JordbrForskn.* 21. 329-356. 1939), that the Live Stock Section of the Association of Scandinavian Agricultural Research Workers appointed a committee commissioned to bring into agreement the different opinions current among younger representatives of the science of feeding regarding the continued development of the food unit calculation. The majority were of opinion that the food unit calculation had won such general confidence and such an extensive practical application that it should be retained in its main features.

Regarding the continued development of the food unit calculation the writer summarizes his views as follows:

1. The unit conception should still be fixed at 1 kg. normal feeding barley, according to Breirem's estimate barley containing 85 per cent dry matter. This unit is already generally known, it is sufficiently simple to be able to be correctly comprehended by everybody, and barley is a fodder which can be fed to all domestic animals.

2. In the first place attention must be concentrated on forming further a food unit designed for valuation of the food stuff in milk production, as this production is the main one in all the northern countries. The food unit should be a total expression of the total effect of the food stuff in that production and therefore applicable also in valuation of the food stuff in control societies in agricultural statistics, in the feeding stuff trade and different forms of economic calculations.

This general food unit calculation can in practice—at least provisionally—also be used in the estimation of the value of the food stuff for different classes of animals and trends of production, because the food stuff, which owing to its high content of fibre cannot be utilized fully by, for example, pigs and hens, is used for these classes of animals in very small amounts and chiefly on account of its special effects.

3. The calculation of the starch equivalent and net energy according to the Kellner-Breirem system estimates only the effect of the food stuffs in fattening of fully grown ruminants and is therefore not the expression of their total effect. It must for the rest be considered as established that the capacity of fat cattle to utilize the feeding stuff lies about 20 per cent lower than that of milch cows and growing fatting pigs.

The starch equivalent and net energy give, however, in the case in point a total expression of the effect of the nitrogen-free nutrient and are, therefore, when the protein requirement in each case is regulated, fully utilizable as a basis for the making up of the rations of domestic animals.

4. A continued investigation of the effect of the various food stuffs on different classes of animals and trends of production is necessary. It should also seek to elucidate further the influence of the different food stuffs on animal products. To

change now in practice to different food unit scales for special classes of animals would, however, cause confusion and should preferably be avoided.

All estimation of the nutritive value of feeding stuffs postulates as certain knowledge as possible of their composition, digestibility and effect. Therefore the following requirements must be realized.

5. Accurate average analyses of our most important and most generally used feeding stuffs must be worked out and placed at the disposal of the public.

All our feeding stuffs, both home-produced and bought, undergo changes in their composition under the influence of new cultural methods, changed times of harvesting, the result of plant breeding, new technical processes, etc. The work of new guiding average analyses can therefore never cease.

6. Continued adjustment of the older digestibility figures is necessary.

These are based to a great extent on international experimental material instead of on indigenous and Scandinavian material. Digestibility is displaced for the rest in connexion with changes in composition and time of harvesting. A pre-requisite for the carrying into effect of this adjustment is that the results of all the disgestibility trials conducted in the northern countries should be published as soon as possible.

7. A continued adjustment of values for the different feeding stuffs must also be carried out.

These too are changed by the same causes as the digestibility figures. Adjustments must be based essentially on direct results of trials with animals. Axelsson's method mentioned above can be used in the estimation of values of different quantities of the same feeding stuff and also feeding stuffs which have not yet been included in accurate feeding trials.

FODDER POTATOES

[Reviewer: R. Peter Jones]

Two articles have recently been published in *Lantm. Svenskt Land.* on the fodder value of the potato and the cultivation of the crop for this purpose. H. Winkler deals more particularly with the latter aspect in Vol. 24. No. 13. pp. 291-2. 1940, while J. Axelsson discusses the value and suitability of the potato for use as fodder on pp. 292-4 of the same issue. Full translations of their remarks are given below.

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According to Winkler, the potato is undoubtedly the highest yielding fodder plant in the wooded districts of Norrland and Svealand. It can therefore here very advantageously be employed in the winter fodder ration as a substitute for turnips which are decidedly more unreliable in cultivation, make greater demands on labour and give a lower yield.

Hitherto the potato has had its most important use as fodder in the piggery. As fattening-food for pigs it can very advantageously be grown in all parts of Sweden.

By practising rational methods, it is possible in the cultivation of potatoes for fodder to attain hectare yields of 25,000 to 30,000 kg. (= at least 5,000 to 6,000 food units). For comparison it may be mentioned that a hay yield of 5,000 kg. per ha. corresponds to about 2,200 food units and an oat yield of 2,500 kg. grain per ha. to 2,100 food units. A turnip yield of, say, 50,000 kg. per ha.—which, however, is by no means easily attained as an average of a five or ten-year period under similar cultivation conditions as the potato—contains 4,000 food units.

In potato cultivation the maximum consumption of labour is concentrated on harvesting the crop. The type of machine in current use effects considerable saving of labour, but an improved implement is called for.

In the cultivation of fodder potatoes, varieties with the highest possible yielding capacity, high content of dry matter, good storage qualities and resistance to diseases during the growing period should be sought. It is to be hoped that Swedish plant breeders will be able to produce varieties of fodder potatoes with an improved protein content.

For cultivation in the southerly parts of Sweden, a number of high yielding varieties are obtainable, Parnassia, Voran, Stärkereiche I, Ackersegen, etc.

Peat soils and clay soils, on which potatoes are liable to be of inferior flavour and quality, should therefore be used in the first place for the cultivation of fodder potatoes.

To obtain high yields complete and liberal manuring is essential. The deterioration in taste and appearance (large tubers) which is a consequence of heavy manuring is no drawback here. In addition to a regular application of farmyard manure of 30 to 40 tons per ha. one should generally speaking give 200 to 300 kg. superphosphate, 150-200 kg. 40 per cent potash salts, together with 200 to 300 kg. saltpetre or sulphate of ammonia, all per ha.

The potash salts—as also the superphosphate—should be spread on the untouched ridge as early as possible so that the greater part of the chlorine is washed out by the spring rain. This appears otherwise to have the effect of reducing the starch content.

Sprouting and early setting are of special importance in the cultivation of fodder potatoes.

As the size of the tubers is without significance in the production of fodder potatoes, the distance between the plants should be slightly greater than usual. A distance of about 70 cm. between the rows and of 30 to 40 cm. in the row gives the highest yield of tubers. The seed potatoes should be of regular size.

* * * * *

Axelsson states that in large parts of the south Swedish uplands the potato is regularly cultivated so extensively that considerable quantities are used annually as fodder. In large areas of the country on the other hand cultivation is so restricted that only exceptionally is this crop available for fodder. This applies in particular to the central and northern parts of Sweden. During recent years, however, in certain places the cultivation has shown a tendency to increase.

The number of varieties grown in Sweden is relatively large. As these are characterized by varying dry matter content, the nutritive value also presents certain differences. On the average the dry matter content in potatoes for human consumption can be reckoned as about 21 per cent and that in fodder potatoes as 25 per cent. These averages are however influenced by many factors, especially soil, manuring and degree of ripeness.

The digestibility of the potato is to be characterized as high, due principally to the low content of fibre. For cattle 81 to 82 per cent of the organic matter is digestible where raw potatoes are concerned. For pigs digestibility is still higher, for raw potatoes 84 to 85 per cent and for boiled potatoes 92 to 93 per cent of the organic matter being digested. For poultry the digestibility of the organic matter for boiled potatoes amounts to 81 to 82 per cent. These co-efficients indicate that for pigs raw potatoes are much inferior to boiled potatoes. Further they show that pigs utilize the potato better than other classes of animals are able to do. Next in order come horses, while ruminants are approximately on a level with poultry.

Usually about 4 kg. potatoes are reckoned to be equivalent to 1 food unit. The amount varies with the dry matter content and the method of use. It is influenced also by the kind of animal: for pigs the reduction figure is lower than for cattle.

As to the potato's fitness for use for different classes of animals, horses occupy, as stated above, an intermediate position between cattle and pigs where utilization of this crop is concerned. Provided the potatoes are healthy and well cleaned, they can be used for horses, irrespective of whether they are raw or boiled. In the former case the amount should usually be limited to 4 to 5 kg. per horse per day, while in the latter case the amount may be increased to 8 to 10 kg. In moderate amount this fodder is suitable for all horses, but particularly for cart horses.

Cattle can with advantage receive some potatoes in their feed: usually they are given raw. They should be cut or crushed before feeding to the animals. The quantity of raw potatoes per cow per day varies between 10 and 20 kg.

Pigs utilize the potato more fully than any other class of animal. Where this fodder is used in large amount for pigs, it should always be boiled: small quantities may be fed raw.

Ensiling has the advantage that the total quantity of potatoes intended for the pigs can be boiled in the autumn, whereby labour is saved, and at the same time storage losses are reduced. The addition of acid is usually unnecessary.

Poultry are able to utilize the nutriment in boiled potatoes comparatively well, particularly fattening birds. Small amounts can with advantage be included in the rations of growing and laying hens also, provided that at the same time the protein content is maintained. Experiments have shown that for laying hens 40 to 50 grm. of potatoes can be given in the daily feed.

Frozen potatoes can also be ensiled following boiling. As a rule the use of such potatoes should be restricted to pigs, although they may also be fed to hens.

GREEN MANURE AND CLOVER SICKNESS

[Reviewer: R. Peter Jones]

The opinions of G. Nilsson-Leissner and H. Winkler on the use of *Trifolium pratense* and *Medicago lupulina* as green manuring crops are given in *Lantm. Svenskt Land* 23. 1165-6. 1939.

According to G. Nilsson-Leissner there is no doubt that the cultivation of red clover and yellow trefoil as green manuring crops suggested by Zachrison in the current volume of this Journal (pp. 1138-9) increases the risk of clover sickness at all events as far as clover stem rot is concerned. As is known this disease attacks in particular newly sown clover and yellow trefoil. In favourable weather the attack may begin in the spring and continue during the whole summer, reaching its maximum during the autumn months and milder periods during the winter. Unfortunately the attack must then most frequently reach "its acute stage" before the ploughing in of the green manure in October or the beginning of November, although the results of this attack are possibly not fully apparent until the plants have withered and died.

What has been said about clover stem rot can, broadly speaking, be considered to apply also to the clover eelworm, although this pest generally spreads much more slowly. As clover stem rot and the clover eelworm are the two principal causes of clover sickness, the conclusion arrived at is that through cultivation of the above-

mentioned green manuring crops the risk of an increase in clover sickness is heightened. This can however be countered to a considerable extent by growing resistant strains of red clover, for example, Svalöf Mercury.

H. Winkler states that, although no practical experience is available concerning the extent to which an extra clover crop intended to be ploughed in during the autumn can be expected to entail an increase in the parasitic diseases of clover, "clover sickness," there is every reason to suppose that such a method of procedure *more generally* adopted would result in a considerably increased frequency of the parasites of different kinds which are believed to cause the so-called "clover sickness," in the first place the clover stem rot fungus (*Sclerotinia trifoliorum*), possibly also the clover eelworm (*Tylenchus devastatrix*) and perhaps also some other fungi, *Typhula*, *Mitrula* etc. At all events this can be expected to be the case in South Sweden, where clover sickness constitutes so great a danger for the growing of clover that for this reason it is considered that a clover crop should not be cultivated on the same field more frequently than every seventh or eighth year.

In this connexion it should in particular be borne in mind that only markedly early red clover can be used, and this must continue to grow as long as possible to give rise to as *vigorous and luxuriant a stand* as can be obtained. These constitute in all respects the best conditions for clover stem rot infection and the further spreading and growth of the fungus. Experience has shown that such clover has been attacked as early as September and October, thus at least one or two months before the contemplated ploughing in.

The result of a more general distribution and use of early, imported red clover would have the result that out on the farms the valuable indigenous local strains would be exposed to admixture with this cheap imported seed which is much less valuable for Swedish hay leys.

The method of green manuring—derived more particularly from Germany—has never become general in Sweden.

Nitrogen—green manuring's main effect—is the plant nutrient of which an actual deficiency can in the last place be expected to occur.

CONFERENCES

West African Agricultural Conference

The Third West African Agricultural Conference was held in Nigeria, in June, 1938. The papers and proceedings have been published in two volumes (see under Books and Periodicals, West African Agric. Conference, *Herb. Abstr.* 10. No. 4. 1940). The following papers were read and bibliographical details will be noted in the above number of *Herbage Abstracts*.

Briggs, G. W. A review of experimental and extension work carried out at the Yandev Agricultural Station, Benue Province.

Hartley, K. T., and Ross, S. D. Feeding of Nigerian stock.

Mayo, J. K. Resumé of botanical work carried out in the Northern Provinces.

Brown, J. D. Shika Stock Farm. Inception and development.

Webster, C. C. Ibadan Agricultural Station, Moor Plantation. Experiments on the maintenance of soil fertility by green manuring.

Henderson, L. P. Review of Nkwele Farm work, 1930-37, with special reference to experiments on maintenance of soil fertility and extension green manure trial plots.

Ross, S. D. Samaru Experimental and Stock Farm. Summary of crop experiments.

Palmer, J. H., and Gibbon, M. W. Review of experiments. Kano Agricultural Station. 1925-38.

Steemson, B. T., and Line, C. W. J. Preliminary report on the possibility of the utilization of sheep for mixed farming in the forest and adjacent country. [Gold Coast.]—M.H.

Marshland Conference at VASHNIL

An agrochemical session of the Academy of Agricultural Sciences (VASHNIL) met at Minsk on September 25-28 (*Himiz. Soc. Zemled.* 1939. Nos. 2-3. pp. 108-11). Of the nineteen reports read, nine dealt with the chemistry and improvement of peat soils, five with the use of fertilizers for various crops cultivated on peat soils, four with the agricultural utilization of peat marshes in various parts of the Union, and one with the peatland resources of the U.S.S.R.—M.A.O.

Maize Conference at VASHNIL

This conference, held in Moscow on the recommendation of the National Commissariat of Agriculture in U.S.S.R. (NarKomZem) and the Academy of Agricultural Science (VASHNIL) on October 25 to 28 (*Jarovizacija* 1939. No. 5/6. pp. 226-9), was opened by Bilinskiĭ (NarKomZem), who reported on the agro-technical methods of increasing the yield of maize; he pointed out that maize may become one of the most profitable grain crops, and discussed the mechanization of its cultivation in detail. Mechanization was also dealt with by Zaharčenko (NarKomZem) and Kaplan (Institute of Mechanization and Electrification of Agriculture, Moscow).

Considerable discussion was devoted to the recommendations regarding artificial pollination, which were made by Musiĭko (Institute of Plant Breeding and Genetics, Odessa). It was pointed out that repeated artificial pollination increased not only seed setting, but also the productivity of the plants derived from seeds obtained in this way. Artificial pollination and inter-varietal hybridization were supported by Acad. T. D. Lysenko, who also discussed questions of organization of seed production, and refuted the suggestion put forward by Acad. P. N. Konstantinov and others regarding the method of increasing seed setting by removal of panicles in every second row of the crop.

Ponomarenko (NarKomZem of Ukraine) and Vovčenko (Regional Agrarian Department, Odessa) drew attention to the incongruity in the present distribution of varieties. Sterling, the most productive variety in the Ukraine, occupies not more than 3 to 4 per cent of the total area under the crop, while " Brown County " Gruševskaja," " Minnesota " and other less productive varieties occupy the remainder of the area.

In addition to hybridization, to which several reports were devoted, Mednjak (Regional Agrarian Department, Dnepropetrovsk) drew attention to the great importance of producing varieties with short vegetative periods, particular attention being given to the discussion of methods of shortening the vegetative period and to vernalization.

Agronomic questions, concerned particularly with the rate and method of seeding and nutrition, were discussed in many reports (Gnilovyĭ, Ponomarenko, Tarasenko, Salamov and others). " Fractional " application of fertilizers and the regulation of the ratio between male and female florets by means of " fractional " fertilization were reported by Acad. I. V. Jakuškin, and in greater detail by Dr. Drozdov.

The Conference concluded with a detailed report by I. D. Kolesnik (VASHNIL) on millet, another forgotten, but nevertheless promising, grain crop in the Union.—M.A.O.

Indian Science Congress

Summaries of addresses of Presidents of Sections are given in *Current Science*. Vol. 9. No. 5. Suppl. pp. 261-6. 1940.

The main theme of the address by the President of the Agricultural Section, Prof. J. C. Luthra, was the importance of seed as a factor in crop production and related problems. The following are among the points made. Lyallpur experiments with *Trifolium alexandrinum* show the value of colour as an indication of viability, and of high fodder-yielding capacity. . . . . Vernalization affords some scope in the acclimatization of promising exotic plants and varieties ; distinct earliness was induced in sorghum and in mustard, in experiments conducted at Rohtak and Almore. . . . . Work in the Punjab and elsewhere on the influence of climatic and soil factors on the nutritive value of grass, especially in raising the protein, calcium and phosphatic content is summarized.—R.O.W.

Sixth Plenary Meeting on the Far North

The sixth plenary meeting of the Committee of the Far North at the Academy of Agricultural Science held in Moscow on February 25 to March 4 was devoted to the problems of the agro-technique of agricultural crops in this region. The following main reports were read.

Tkačenko, N. S.	The chief measures for increasing yield in the Far North.
Ciplenkin, E. I.	Methods of increasing yield of grain crops in Jakutian A.S.S. Republic.
Turnas, P. A.	Crop rotation and agro-technique in the Murman region (results of research at the Polar Station, Hibiny; and local State and collective farms).
Skalozubova, A. N.	Agro-technique to be emphasized for producing high yields in the Ostyak-Vogul Region.
Tjurdenev, A. P.	The agro-technique in the most advanced collective farms in the region of the Far North.

Several short reports were also communicated from the Kamchatka Experiment Station (Titljanov), the Experiment Farm at Jarcevo (Loskutov), Narjan-Mar Experiment Station (Kruglikov), Narym Experiment Station (Karpovič), Pechera Experiment Station (Ročev), and some other institutions. The resolutions and recommendations passed have been published as a pamphlet edited by I. G. Eichfeld and D. M. Trošin, and are summarized as follows : The chief measures for increasing yield in the Far North (concerned chiefly with problems of organization of rural husbandry and agricultural research) and mechanization of rural husbandry in the

Far North (agricultural machinery for soil reclamation and cultivation, field crops, vegetables, potatoes and hay making and fodder production).

The same pamphlet also contains the resolutions and recommendations passed by the fifth plenary meeting in connexion with Eichfeld's report on "Plant breeding and seed production in the Far North."—M.A.O.

Scottish Conference on Grassland Improvement

The *Scottish Journal of Agriculture*, Vol. 23. No. 1. 1940, contains an account of the Conference on Grassland Improvement organized by the Department of Agriculture for Scotland, and held in Edinburgh from 9 to 11 April, 1940.

In his presidential address, Mr. P. R. Laird, C.B., stressed the importance of grassland for increased food production. From a total area of 4.6 million acres of farm land in Scotland, 1.5 million acres are in rotation grass, 1.6 million acres in permanent grass, and there are also 10.6 million acres in rough grazings. Methods of improvement that can be applied to the first two types of land are drainage, ploughing and re-seeding, surface treatment and grazing management. Rough grazings can be improved by draining, heather burning, bracken cutting and well-planned stocking.

The following nine papers were read and will be abstracted in *Herbage Abstracts* 10. No. 4. 1940 :

Watson, J. A. S. The improvement of grassland in relation to agriculture in general.
Home, Sir John Milne. The stocking of hill grazings.
Watson, S. J. Ensilage and grass drying.
M'Dougal, A. R. Some practical experiences of grassland improvement.
Braid, K. W. The eradication of bracken.
Heddle, R. G. The results of surface harrowing compared with those of ploughing.
M'Intyre, J. C. F. Cultural operations in the establishment of permanent pastures.
Robertson, I. M. The chemical aspect of grassland improvement.
Gregor, J. W. Seed mixtures for re-seeding.

Royal Society of Canada

A report of the annual meeting of the Society held at the University of Western Ontario from May 20 to 22, 1940, is published in *Science* 92. 119. 1940. The presidential address, "A study of the organization and work of the Royal Society of Canada" was delivered by Dr. H. M. Tory.

The presidential address to Section V, (Biological and Medical Sciences) on the subject of "The causes of hybrid sterility and incompatibility" was delivered by Prof. W. P. Thompson, of the University of Saskatchewan, and stressed particularly the time in the life-cycle at which the causes may operate. Botanical papers included two by Prof. E. H. Moss on interxylary cork in *Artemisia*, while Prof. G. W. Scarth summarized work on frost and drought resistance carried out with J. Levitt, B. Siminovitch and others, and described the changes in the physical state of protoplasm associated with hardening.

Central Fodder and Grazing Committee, India

The Fourth Meeting of the Committee was held in June, 1940 (see *Herb. Rev.* 8. 104-5. 1940). In addition to a number of research schemes, the Committee considered the question of the co-ordination of work on fodder and grassland research ; after accepting the suggestion that fodder and grazing problems be considered under three heads, i.e., 1, Production ; 2, Nutrition ; and 3, Economics, the following recommendations were made under each :—

1. *Production.*

It was agreed that it was necessary to distinguish between cultivated fodders and uncultivated fodders or grasses.

(*a*) *Cultivated fodders.* Future work on cultivated fodders which should be carried out both at Agricultural Stations and Cattle Farms should take the form of standardized patterns of experiments and the Statistician to the Council should send out a standard model for trial.

(*b*) *Breeding.* (i) In the absence of an Agrostologist, work on breeding could not be proceeded with satisfactorily and should therefore be omitted from the programmes for the present. (ii) Work designed to increase the proportion of good grasses in grazing lands might be continued. The sowing of additional seed of good grasses as a part of management should be tried where feasible, causes for poor germination simultaneously studied, and the question of weeding investigated.

(*c*) *Feeding.* In the case of tree fodders and natural grasses, the nutritional value of which is not known, the nutritional aspect should be studied simultaneously with cultivation experiments.

(*d*) *Disease.* The question of certain areas of grassland harbouring parasites, etc., with consequent bad effects on animals grazing there should be studied, particularly in wet areas, and experiments should be carried out only in those areas where the problem occurred. It should preferably be undertaken in connexion with management schemes and in collaboration with a parasitologist.

(*e*) *Management.* Grassland improvement by means of management should be pushed on. Schemes on this should indicate provisions for

(i) control of grazing animals regarding number and nature and the provision of salt, water, shade, etc.;
(ii) control of grazing areas by dividing them into blocks which should be provided with fencing or its equivalent for schemes outside reserved forests;
(iii) time and period of closing and opening of each block;
(iv) anti-erosion measures;
(v) reseeding;
(vi) alternation of cutting and grazing;
(vii) burning;
(viii) dung-spreading.

(i) to (iv) should be obligatory in all schemes and (v) to (viii) may be included wherever desirable.

(*f*) *Utilization of grasses.* Work on the utilization of grasses produced as grazing, as hay and as silage and where possible as artificially dried grass, should normally be commenced.

(*g*) *Village grazing areas.* The Committee recognized that there were three types of land that were required to be dealt with in this connexion, namely: (i) assembling places (i.e., mere stamping grounds); (ii) land classified as waste adjoining villages, and (iii) forest grazing areas.

(i) The Committee felt that little effective work could be done due to overcrowding, except in clearing out unproductive shrubs and planting trees wherever feasible.
(ii) In regard to lands classified as waste, some form of control was necessary, and this should be included in the scheme itself as part of the developmental work. Government should take steps to introduce controlled grazing in these areas. In cases where such land belonged to Government and was leased to other agencies such as special co-operative societies, cattle breeding societies or gowshalas, it should be a condition of the lease that rotational grazing and the provision of silage should be attended to by the lessee.
(iii) In regard to grazing lands in forest areas, the Committee recommended that these areas should be improved and grazing thereon should be properly controlled. Although they affected only a small cattle population, full use should be made of them as demonstration areas for grassland management combined with stock raising.

2. *Nutrition.*

The Committee accepted the suggestions that :—

(*a*) The chemical analysis of fodder and soils should be carried out if and when desirable in connexion with feeding experiments. It would be an advantage to have as much data on the subject as possible, collected from different parts of the country.

(*b*) Biological analyses should be undertaken in specially equipped laboratories and in localities where conditions permitted.

(*c*) Digestibility trials should be undertaken in properly equipped nutrition stalls and laboratories in the case of those fodders whose feeding values are not known.

3. *Economics.*

In regard to cultivated fodders, the economics of labour, manures, etc., should be worked out. As regards grasses, this should be included in the extension work.

4. *General.*

Work on the three aspects of the problem, namely, Production, Nutrition and Economics, are all inter-related and research on any one problem will not be complete unless the other two aspects of the problem are also tackled. These need not be undertaken at any one centre, but fundamental work may be done in one or two selected centres and the more ordinary trials and the application of fundamental knowledge may be carried out at a wider range of stations.

A number of schemes dealing with grassland problems from Bombay, Sind and the Punjab were considered and some were recommended to the Governing Body for sanction.

Ecological Society of America

The following were some of the papers read at the Summer Meeting of the Society, held at Seattle, Washington, on June 19 to 21, 1940, with the American Association for the Advancement of Science and its divisions.

The terminology of plant sociology. William E. Lawrence, Oregon State College, Corvallis, Oregon.

Vegetational and soil changes introduced by overgrazing on certain ranges of the Palouse Prairie of Northwestern Idaho. Vernon A. Young, University of Idaho, Moscow, Idaho.

Vegetative succession following logging in the Douglas fir region. Leo A. Isaac, Pacific Northwest Forest Experiment Station, Portland, Oregon.

Soil factors in land use problems. Lawrence C. Wheeting, State College of Washington, Pullman, Washington.

Land use problems and policies in the Columbia Basin Irrigation Project. S. E. Hutton, Bureau of Reclamation, Coulee Dam, Washington.

Studies on the wilting behaviour of woody desert legumes. R. F. Daubenmire and H. Charter, University of Idaho, Moscow, Idaho.

The grassland and related formations of northern Mexico. Forrest Shreve, Carnegie Institution of Washington, Tucson, Arizona.

Plant succession from the standpoint of economics. William E. Lawrence, Oregon State College, Corvallis, Oregon.

Agro-ecology as a basic science of agriculture. Basil M. Bensin, Russian Agricultural Association of North America, New York.

American Society of Plant Physiologists

The following were some of the papers read at the Tenth Summer Meeting of the Society, held at Seattle, Washington, on June 18 to 22, 1940 :

Symposium : Phosphate nutrition and phosphate fertilization.

The behaviour of phosphorus in soil colloidal systems. Perry R. Stout, University of California, Berkeley.

The absorption of phosphate from the soil by the plant. J. S. Burd, University of California, Berkeley.

The behaviour of phosphorus in plant systems. O. Biddulph, State College of Washington, Pullman.

Soil-plant interrelationships concerning phosphate. W. T. McGeorge, University of Arizona, Tucson.

Symposium : Recent investigations of the characteristics of the photosynthetic process.

The relation between respiration and photosynthesis. Hans Gaffron, University of Chicago.

The quantum efficiency of photosynthesis as an approach to the interpretation of the process. Robert Emerson, Carnegie Institution of Washington, and California Institute of Technology.

Carotenoid-sensitized photosynthesis in the marine diatom, *Nitzchia closterium*. Winston M. Manning and Herbert J. Dutton, University of Wisconsin.

Radio-active carbon in the study of photosynthesis. S. Ruben, University of California.

Symposium on photosynthesis.

The chlorophyll-carbon dioxide ratio in purple bacteria photosynthesis. William Arnold, Hopkins Marine Station, Stanford University.

A unified concept of the chemistry of photosynthesis. C. B. van Niel, Hopkins Marine Station, Stanford University.

Simultaneous measurements of rate of photosynthesis and intensity of fluorescence. E. C. McAlister and Jack Myers, Smithsonian Institution.

Some effects of sodium and potassium fluoride on bean seedlings. O. Biddulph, State College of Washington.

American Dairy Science Association

The programme of the thirty-fifth annual meeting of the Association held at Purdue University, West Lafayette, Indiana, on June 24-28, 1940, is published in the *Journal of Dairy Science*, Vol. 23. No. 6, June, 1940.

Papers presented to the sections on nutrition, and minerals and vitamins included some of direct fodder interest. [Abstracts of these communications are given on pp. 555-75 of the same issue ; short extracts will be included in *Herb. Abstr.* Dec., 1940.]

Studies with barn air-cured alfalfa hay. C. E. Wylie, S. A. Hinton, and J. A. Schaller, University of Tennessee and Tennessee Valley Authority.

Dried grapefruit pulp for milk production. P. T. Dix Arnold, R. B. Becker and W. M. Neal, Florida Agricultural Experiment Station.

Alfalfa hay cut at three stages of maturity ; its yield, chemical composition and feeding value for milk production. J. R. Dawson, D. V. Kopland, and R. R. Graves, Bureau of Dairy Industry, U.S. Dept. of Agriculture.

Cystine as a possible deficiency in a ration of alfalfa hay for milk production. C. F. Huffman and C. W. Duncan, Michigan Agricultural Experiment Station.

The feeding value of rye stillage for dairy cows. K. L. Turk and M. H. Berry, Maryland Agricultural Experiment Station.

Fermentation studies on alfalfa silage prepared by the phosphoric acid and molasses methods. H. D. McAuliffe, R. W. Stone and S. I. Bechdel, Pennsylvania State College.

The losses resulting from the ensiling of legumes and grasses with varying amounts of phosphoric acid. O. L. Lepard and E. S. Savage, Cornell University.

Effect of depth of corn in the silo on weight of corn silage. Joseph B. Shepherd, Bureau of Dairy Industry, U.S. Dept. of Agriculture.

Broomcorn silage for dairy cattle. K. E. Harshbarger and W. B. Nevens, University of Illinois.

Comparison of *Lespedeza sericea* silage, alfalfa silage, and corn silage for dairy cows. S. A. Hinton and C. E. Wylie, University of Tennesse.

Composition and nutrient value of sugarcane as fresh forage, shocked fodder and silage. W. M. Neal, Florida Agricultural Experiment Station.

Is timothy hay adequate in calcium for optimum growth of dairy heifers ? H. T. Converse, Edward A. Kane, and Edward B. Meigs, Bureau of Dairy Industry, U.S. Dept. of Agriculture.

Vitamin E potency of certain feedstuffs. L. S. Palmer, J. W. Nelson and T. W. Gullickson (with the assistance of B. B. Migicovsky and W. W. Kielley), University of Minnesota.

Carotene content of corn silage. Edward A. Kane, Herbert G. Wiseman, Leo A. Shinn, and C. A. Cary, Bureau of Dairy Industry, U.S. Dept. of Agriculture.

The vitamin A requirements of dairy cows for the production of butter of high vitamin A value, II. Relative efficiency of carotene (dehydrated alfalfa hay) and vitamin A. J. W. Wilbur, J. H. Hilton and S. M. Hauge, Purdue University.

ANNOTATIONS

Great Britain (410)

Sir Frank Stockdale

Consequent upon the appointment of Sir Frank Stockdale as Comptroller for Development and Welfare in the West Indies, Dr. H. A. Tempany has been appointed Agricultural Adviser to the Secretary of State for the Colonies.

Agricultural and Horticultural Research Station, Long Ashton

The Annual Report of the Station for 1939 contains a progress report by S. H. Bennett on experiments made on control of the chafer beetle, *Phyllopertha horticola* L. in grassland.

Grassland on the lighter, well-drained soils is most subject to attack, particularly meadows that are left rough and not mown or grazed until late in the season. First symptoms are the presence of birds searching for the grubs, or characteristic spongy surface caused by loss of roots. Damage consists of a direct loss of hay or pasture herbage and subsequently of more serious loss in the quality of the turf due to development of the coarser grasses.

None of the insecticides tested was sufficiently toxic at economic or safe concentrations. The most economic procedure is to plough the infested pasture in September to expose the maximum number of larvae to the birds. Grassland on types of soil subject to regular infestation should be restricted to short leys of not more than 7 years' duration.—M.H.

Isle of Man Board of Agriculture

The Report of the Board for the year ended 31 March 1940 supplies the following information on seed production from single acre plots sown in drills :

	Lolium perenne S101	*Festuca pratensis* No. 23	*Phleum pratense* No. 2.	*Dactylis glomerata* S26
	Per cent	Per cent	Per cent	Per cent
Purity	98.1	79.95	91.6	91.0
Injurious weeds	Nil	Trace	4	Trace
Other weeds	Trace	0.05	2	0.5
Useful seeds	Trace	0.5	2	1.0
Inert matter	1.9	1.5	0.4	7.5
Germination	59	not yet known	94.5	95.5
Gross yield per acre ..	4 cwt. 31 lb.	1 cwt. 63 lb.	1 cwt. 49 lb.	1 cwt. 85 lb.

U.S.S.R. (47)

Soviet Atlas of the World

The second volume of this atlas contains politico-administrative, survey, economic and physical maps of the Union, as well as maps of the history of the Civil War (Sovetskie Kniznye Novinki, Nos. 7/8, 1940, Moscow).

The full reference to the Atlas is as follows: Boljšoĭ Sovetskiĭ Atlas Mira. [The Major Soviet Atlas of the World.] Vol. 2. 143 pp. maps × 8 pp. of explanatory text. Izd. Gugk. $95.50.

Agricultural Exhibition

As already noted (*Herb. Rev.* 8. 110. 1940), the Agricultural Exhibition is to be an annual event in U.S.S.R. The seven numbers already received of *Bull. glav. Kom. Vsesojuz. Vyst.* (issued by the Principal Committee of the Agricultural Exhibition), contain descriptions of new features in last year's pavilions and in the new pavilions to be opened in the summer of 1940. Articles on the second year of opening of the Exhibition in Moscow have also appeared in practically all agricultural periodicals.—M.A.O.

Leningrad University

The St. Petersburg Imperial University, now the Leningrad State University, was founded on February 19, 1819, and officially inaugurated on November 1, 1819. As distinct from the Universities founded earlier in Kiev, Moscow, Kazan and Kharkov, the new University was given the special task of preparing professors and research workers, and did indeed play a conspicuous part in the history of science in Russia, giving to the country not only renowned scholars (Mendeleev, Sečenov, Steklov, Čebyšev, Marr, Dokučaev, Lebedev, Pavlov, Palladin, Kostyčev and many others), but also a number of outstanding representatives of Russian literature and arts (Černyšev, Nekrasov, Turgenev, Pisarev and others), as well as many sociologists and social reformers, including V. I. Lenin (Uljanov.)

The completion of 120 years of the University has been especially celebrated throughout the Soviet Union, while a special session was held at the Academy of Sciences at which addresses were read by outstanding representatives of science in the Union. A series of articles dealing with the occasion has been appearing in the monthly periodical *Priroda*, published by the Academy of Sciences, and it is upon these articles and particularly upon that by P. V. Terentjev on "Biological science at the Leningrad State University during the 120 years of its existence" (*Priroda* No. 7. 107-12. 1939) that this review has been based.

In the early years of the University the number of students increased slowly, being twenty-seven on the day of its inauguration and 212 in 1835; only after the Crimean war (1854-5) did the number of students exceed 1,500, and began to increase rapidly thereafter. In the celebration year 1939 there were over 6,000 registered students, including over 3,000 women; there were also 430 external students, 410 post-graduate students and 4,500 members taking correspondence courses. The teaching staff numbered 744, including 180 professors, of whom twenty-four were members and twenty-three corresponding members of the Academy of Sciences, 125 were doctors and 335 candidates of science (the first post-graduate degree) and dozents.

During these 120 years the organization of the University was changed on several occasions, thus affecting the position of biology in the general university training.

From 1819 to 1835 the University consisted of three departments, philosophical and juridical, history and letters, and physico-mathematical. The third department comprised seven chairs, including those of chemistry, botany and zoology. From 1835 onwards there were formed two faculties in the University, juridical and philosophical. The latter was divided into the phylological and physico-mathematical departments, the second of which was further subdivided into ten chairs, including those of chemistry, botany, zoology and agriculture with forestry.

From 1842 to 1851 there were some minor changes in the constitution of the University. In the sixties, the period of great social and political reforms in the last century, four faculties were established : history and phylology, eastern languages, law (juridical), and physico-mathematics. The last of these was as before subdivided into two departments which included the chairs of experimental, technical, theoretical and agronomical chemistry, morphology, systematics, anatomy and physiology of plants, comparative anatomy, systematics and, from 1865 onwards, the anatomy of man and animals. This type of organization was retained until 1918, when the University was renamed the First Petrograd University and its physico-mathematical faculty was divided into two departments, physico-mathematics and natural science. In 1920 the physico-mathematical faculty was divided into five departments : physics, mathematics, chemistry, biology and geology. In 1930, a year of far-reaching reforms in the higher education system, the faculty was again reorganized into three independent faculties : mathematics, physics and biology. In 1933 more faculties were added for chemistry and geologo-pedological geography, and in 1934 faculties of history, phylology and geography were included, making a total of eight faculties in the University.

During the past twenty years several research institutions have been opened at the University. These include the Biological Institute at Peterhof, the Physiological Institute, the Chemical Institute, the Biological Station at Sablino, and the woodland reserve of "Les na Vorskle" for geobotanical studies.

Plant systematics

As early as the sixties of last century, two trends became obvious in these studies ; one directed towards the study of the cryptogamic plants was initiated by L. S. Cenkovskiĭ (1822-87) and the other to the study of the higher flowering plants by A. N. Beketov.

The chair of cryptogams produced a number of well-known botanists (Famincin, Voronin, Tranchel etc.) among whom S. N. Vinogradskiĭ was recognized for his studies on nitrogen-fixing and other soil bacteria. H. Ja. Hobi (1847-1919) was also engaged at the University in the study of lower plants. The chair also produced some well-known bacteriologists (Omeljanskiĭ, Isačenko etc.) and cryptogamic botanists (N. A. Naumov, N. N. Voronihin, V. P. Savič, B. P. Karakulin, B. F. Kašmenskiĭ and L. G. Ramenskiĭ, who later became a geobotanist.)

The chair of phanerogamic systematics was for over 30 years, from 1861 onwards, occupied by A. N. Beketov. He was one of the first to interest Russian botanists in Darwin's research. V. L. Komarov and N. I. Kuznecov came from his school and have in turn laid the foundations of the modern school of systematists-evolutionists. The chair is now held by Acad. Komarov, who is also well known for his studies of the flora of the Far East of the Soviet Union, and on the origin of cultivated plants, and whose 45 years of scientific life and 25 years of editorship of *Priroda* were officially celebrated on his seventieth birthday (October 13, 1939). Experimental systematics is being rapidly developed under M. A. Rozanova, while studies in phytogeography are supervised by N. A. Busch.

Geobotany

Geobotany began to exist as an independent study some 25 years ago, when A. P. Šennikov began to lecture on methodology in geobotanic studies. From 1924-5 onwards the scope of lectures given by Šennikov was extended, while A. P. Iljinskiĭ began to lecture on forestry. In 1925 these two branches were united under the chair of phytosociology directed by V. N. Sukačev, who lectured on phytosociology and marshlands. N. I. Kuznecov initiated lectures on phytogeography and later on plant ecology. From 1930 onwards his lectures in plant ecology were taken over by G. I. Poplavskaja and I. M. Krašennikov, who began to lecture on the steppe and the deserts ; B. N. Gorodkov on tundra and V. A. Dubjanskiĭ on sandy lands. In 1931-2 all these diverse studies in geobotany were amalgamated into a single geobotanical group which increased in size with the years and formed the chair of geobotany in the present Biological Faculty directed by Sukačev.

This department organized sixteen expeditions to the south of Russia, Crimea, Col peninsula, Kazakstan, Altai, Caucasus and Tian-Shan ; some of the results of these expeditions have been published. In the Peterhof Institute studies of experimental botany are being extended under the supervision of A. P. Šennikov.

Plant physiology

Lectures on the physiology and anatomy of plants were begun in the sixties of last century by N. E. Zabel and A. S. Famincin ; the latter published in 1887 the first original Russian text-book on plant physiology. I. N. Borodin, who succeeded Famincin after his election in 1889 as a member of the Academy of Sciences, was also well known chiefly in connexion with his sensational discovery of the crystals of ethyl-chlorophyllid, then thought to be crystals of chlorophyll. His text-book on plant anatomy, since published in five editions, may also be regarded as a classic. On the election of Borodin to the Academy of Sciences, the chair was for several years held by D. O. Ivanovskiĭ, who was in his turn succeeded by V. I. Palladin, and his assistant S. P. Kostyčev, well known for his researches in anaerobic respiration. Palladin also published a text-book on plant physiology which went to ten editions in Russian, and was translated into English, French and German.

Pupils of Palladin's school included A. N. Danilov, V. P. Maljčevskiĭ, S. D. Ljvov, N. N. Monteverde, N. A. Maximov, N. N. Ivanov, O. A. Walter, B. V. Perfiljev, D. A. Sabinin, V. G. Alexandrov and many other well-known physiologists and anatomists. In 1914-15 the chair of plant physiology was taken over by Kostyčev and held by him until his death in 1931. After an early interest in the genetical relations between aerobic and anaerobic phases of respiration, Kostyčev proceeded to study the chemistry of fermentation and nitrogen absorption, the manufacture of organic acids and many other problems which led to the publication of over 170 papers and a two-volume text-book on plant physiology which was first translated into German and then into English by Lyon, as well as a number of monographs on plant respiration, most of which were translated into German and English. Kostyčev was succeeded by S. D. Ljvov, whose chief interests have been the specific significance of saccharoses, the physiology of the formation of ethereal oils and organic substances in plants.

Microbiology

In 1900 B. L. Isačenko began to lecture on microbiology ; although this course became obligatory in 1911, it was not until 1918 that the subject was normally and fully settled. In 1903 D. Ivanovskiĭ who studied mosaic in tobacco plants, isolated certain hexagonal crystals, which 35 years later were found to be related to the crystals of a virus. In 1906 Isačenko investigated shimmering and the microflora of northern seas, as well as medicinal muds. In 1929 the chair was taken over by N. N. Ivanov, whose investigations were chiefly concerned with metabolism in fungi and bacteria. Z. G. Razumovskaja and others are engaged in the study of the microflora of soil.

Genetics and other sections

Genetical investigations were originated in 1919-20 by Ju. A. Filipčenko, who began studies in reproduction and age variability and later in quantitative characters, chiefly in wheats. These investigations yielded valuable scientific and practical results, and in particular a number of valuable wheat varieties were produced, including Peterhofka and Extra-Preljud. After Filipčenko's death, the laboratory was taken over by A. P. Vladimirskiĭ who himself died in 1939. Recently a special study of plant genetics was separated from this laboratory (chair) and placed in charge of G. D. Karpečenko, who is widely known for his work on interspecific hybridization. Cytological studies are carried on by I. I. Sokalov and I. I. Novikov.

The remaining part of the genetical laboratory (under Vladimirskiĭ) has continued its studies in experimental zoology. As now constituted, the Biological Faculty comprises also the following

seven chairs ; Zoology of Invertebrates, Zoology of Vertebrates, Hydrobiology and Ichthyology, Histology, Physiology of Animals, General Biology and Darwinism. The last of these was initiated in 1938 as a laboratory under the chair of general biology, but in 1939 it was enlarged into an independent chair.—M.A.O.

N. P. Krenke.

It is announced in *Jarovizacija*, No. 1 (28), 1940, that Dr. Nikolaĭ Petrovič Krenke died on November 25, 1939 after a prolonged illness. Dr. Krenke was born in Tiflis, now Tbilisi, in 1892. In 1921 he completed his training in the Agricultural Faculty of the Tiflis Polytechnic, where he remained for two years as assistant lecturer in anatomy and physiology. In 1924 he left for Moscow to continue his research at the Timirjazev Biological Research Institute. At the Botanical Congress in 1926 he read his first report on " Constructive moments in morphogenesis," which attracted considerable interest and was noted as opening up new possibilities in this field. In 1931 he founded around himself a laboratory of developmental morphology (phyto-morphogenesis) of which he remained leader until his death.

In his phenogenetic researches, Krenke was concerned chiefly with the mechanism of ontogenesis and its variability and was able to establish a formative significance of variability. For example, while studying variability in the sunflower, Krenke postulated a formative process in the character of number of cotyledons ; following up his ideas he bred two races, one giving tricotyledonous individuals in addition to dicotyledonous types, and the other dicotyledonous and monocotyledonous individuals ; later, the tricotyledonous races began to produce tetra-cotyledonous types. In his studies Krenke made frequent use of manipulative interference with plant development. In 1928 he published a monograph on "Chirurgy of plants," which was reprinted in 1933 in German as " Wundkompensation, Transplantation und Chimären bei Pflanzen." (Berlin, Verl. v. J. Springer. 934 pp.) In fact, grafting and regeneration played an important part in Krenke's studies. He was the first to show the possibility of grafting monocotyledons with the formation joint between the conductive systems of the grafts.

Krenke was best known for his research in the theory of cyclic senescence and rejuvenescence of plants in ontogenesis ; the first details of this theory were published in one of the chapters of the above-mentioned monograph, and in a revised and completed form in the first volume of " Phenogenetic variability" (1933-1935). This theory assumes a continuous, but irregular process of cyclic senescence ; in the early "ascending" stages, senescence is expressed in establishment of the organism, and in the later "descending" stages in weakening the organism. It is claimed that in every organism there are characters liable to variation with age ; consequently, in the phase of the ageing characters it is possible to determine the age of the organism under actual conditions of life. In the process of general individual senescence the cyclic rejuvenescence occurs. " Rejuvenescence is a new form of development of young substances and structures, and also the retardation of the senescence of the existing elements, but there is no return of either the individual or its parts to the past."

Apart from its biological significance, the theory has certain confirmed practical aspects. It has made possible the determination at early growth phases of the earliness and certain other age characters in annual and perennial plants. It is also possible to define the response of the plants to changes in the conditions in which it is grown. Finally, it provides a guide in selecting components in budding, grafting, cutting and pruning and other manipulative methods. The theory was demonstrated at the Agricultural Exhibition in Moscow in August 1939, and is being published by the Principal Committee of the Agricultural Exhibition. During his short scientific life, Krenke completed many extensive researches, and published over sixty papers. His last work on "Polarity in plants" was completed a day before his death.—M.A.O.

Finland (471.1)

Leteensuo Experiment Station

A report on the root crop trials carried out at the Station during the past ten years is given by A. Vesikivi, the particular aspect investigated being the cultivation of root crops on peat soils (*Finska Mosskförens. Årsb.* 1938. 42. 116-51. German summary, 150-1.) The centre is one of the Experiment Stations of the Finnish Moor Cultivation Society, at which experiments with various root crops have been conducted regularly. It has been possible to grow successfully at Leteensuo on well-decomposed low moor forest peat without nitrogenous manuring, provided liberal amounts of potash and phosphoric acid were given, the most common root crops, turnip, rutabaga, fodder and sugar beet as well as carrots. On slightly decomposed low moor peat as also on high moor peat no satisfactory root crops were obtained.

The cultivation of root crops appears to require a slightly larger admixture of sand and clay (300 cubic metres per ha.) as well as a slightly greater depth of cultivation (about 25 cm.) than is usual with oats and meadow culture. In the rotation a short-duration temporary meadow must always be included, because the highly nitrogenous low moor soil cannot be kept free from weeds if cereal and root crop cultivation is practised continuously, and because low moor soil with the growing of arable crops, which necessitates constant cultivation, becomes too loose if, in the meantime, it is not bound together by means of meadows. Without meadow cultivation it is also difficult to obtain a sufficiently long interval between the root crop harvests, that is, more than six years, which period of time is necessary for cruciferous plants in order to avoid serious plant diseases.

If the ravages of *Phaedon cochleariae* were not so serious as they are at present, the turnip would be the more important root crop on low moor soil, as this plant grows rapidly and is unexacting.

The experimental data show, however, that turnips, at least when grown on low moor soils in South Finland, can be replaced by swedes and carrots (potatoes also can be grown successfully on low moor soil in south Finland).

Further, the experimental results have indicated that the sugar beet has been more profitable than the swede at Leteensuo in plots on low moor soil. The sugar beet has thus in the southern part of Finland, shown itself to be a more reliable fodder plant than the swede with regard to climatic conditions. According to the experiments at Leteensuo the sugar content of sugar beet has been 0.6—1.0 per cent lower on low moor soil than on clay soil. As the sugar beet on good low moor soil at Leteensuo has given on the average a yield of 20,000 kg. per ha. without nitrogenous manuring and in addition the yield of tops has been considerable, the sugar beet could also be grown as a fodder plant on low moor soil of good quality in South Finland, as the raw sugar factories do not utilize sugar beet grown on low moor soil. It should be observed, however, that when feeding sugar beet to milch cows one must not exceed a certain quantity. At Leteensuo it has been noted that the sugar beet (not the tops) gives the butter fat an unpleasant taste when the cows receive more than 5 kg. each per day. This state of affairs has, however, not been demonstrated by scientific feeding experiments.

The author presents a large number of results of liming, manurial- and water-damming experiments, also of experiments with varieties of root crops, time of sowing and singling. Determinations of dry matter from root crops grown on low moor and clay soils were compared with one another, with the result that the root crops on low moor soil were found to be to a certain extent more aqueous, but the abundant crops from low moor soils were grown with low production costs, since nitrogenous manuring was not necessary.—R.P.J.

Norway (481)

Voll State Experiment Station

In the Report from the Station for 1938, P. J. Løvø gives results of trials with turnips and swedes. For location of Voll, see map in Herb. Publ. Ser. Bull. 28 or Imp. Agric. Bur. Joint Publ. No. 3.

Varieties of turnips

The trials show that Dales Hybrid is more valuable than Fynsk Bortfelder under the cultivation conditions prevailing in the experimental area. On the clayey soils at the Experiment Station and in the interior of Trøndelag generally, the variety is only slightly superior. On the other hand, it is much better on soils containing sand which give a smaller yield on the whole. Here Dales Hybrid's superiority to Bortfelder in yield of food units was considerably greater than elsewhere. On good soil of a clayey character and in the warmest and driest districts Fynsk Bortfelder and Dales Hybrid are on an equality.

Dales Hybrid is on the whole unexacting and does not require so much warmth as Bortfelder. The Danish strain is the better. Its storage qualities are quite equal to those of Fynsk Bortfelder.

Østersundom is hardly as successful here as Dales Hybrid, but it is nevertheless a valuable variety. Its requirements in regard to soil, weather and growing conditions are similar to those of Dales Hybrid. It makes very rapid growth and tolerates late sowing better than any other variety.

It is probable that Østersundom would tolerate unfavourable weather conditions even slightly better than Dales Hybrid, and that therefore in rainy districts and in mountainous districts where sowing must be carried out late, Østersundom should be grown rather than Dales Hybrid. It storage qualities are superior to those of all the other varieties. The Danish strain, which is generally obtainable in the market, should be grown.

White early turnip, Forus, is half as rich again in dry matter and food units and gives a larger yield in dry matter and food units than any other variety of turnip. It is an exceedingly valuable variety particularly in the experimental area, although the yield of roots is small.

The Forus turnip has a smaller growth of leaves than Fynsk Bortfelder. It is also a drawback that in singling a smaller distance has to be left between the plants so that there are more roots to lift. Its yield of food units is greater than that of the other varieties.

It surpasses Bortfelder and Dales Hybrid in storage qualities.

Early turnip is grown to a very small extent in the experimental area.

Varieties of swedes

Of the varieties tested only three are of interest in the experimental area: Trønder, Bangholm and Göta. Trønder has not been very successful; at the Experiment Station, Bangholm, Edland has given an increased yield of 115 food units compared with Trønder. Bangholm, Danish, has yielded not far short of 100 food units more. The Svalöf strain, which has given quite as large a yield as the other two, is difficult to obtain in the market in the north of Norway. Broadly speaking, the cultivation value of all three Bangholm strains is the same.

Göta swede, Holmberg, has given a much larger yield of roots than Trønder and the best Bangholm strain. The leaf yield is slightly slower than in Bangholm, but in spite of this it has given the largest yield of food units. During the two years when it was included in storage trials it gave good results.

How much space should be left between the plants in singling?

Dales Hybrid and Fynsk Bortfelder have given the largest yield of food units with distances apart of 20 and 25 cm. Dales Hybrid appears to do best at 20 cm. apart. It is hardly remunera-

tive to grow either of these varieties at less than 25 cm. apart. With swedes the smallest distance apart (15 cm.) has given the largest yield of food units, but the difference in yields following different distances apart has not been particularly great. The intermediate distance of 20 cm. is recommended.—R.P.J.

Root crop seed supply

A discussion of the position is given by J. H. Lund in *Norsk Landbruk*. 6. 118-9. 1940.

The first world war found Norway unprepared to meet the seed requirements of her farmers. This resulted in the establishment of a considerable indigenous seed production. Although the material used was frequently somewhat unreliable and the workers were unskilled, still in 1917 and 1918 no fewer than 1130 dekar were sown for trade seed production of swedes and turnips.

During the years following the world war, the work of seed production was continued, and at the same time this work was extended by an organized stock seed production to obtain a good and reliable basis for the production of trade seed.

In the course of time Norway's own seed production of swedes and turnips was sufficient to cover half the country's seed consumption. At the same time a promising seed production of fodder beet was established.

During the last few years, however, indigenous seed production has been reduced to such an extent that it is now of no significance. In 1939 there was of swedes, turnips and fodder beet a seed production which probably can be computed at 12 to 15 tons, while annual consumption amounts to approximately 230 tons.

In the summer of 1939 an arrangement was made between the Department of Agriculture and the Norwegian importers of seed regarding emergency storing of seed of swedes, turnips and fodder beet. This emergency store is to be a reserve large enough to cover one year's consumption. Further, as long as the emergency storage of seed of root crops continues, permission to import seed of these kinds of plants will not be given to other importers than those who co-operated in the storing. Emergency stores are under public control and the addition or withdrawal of lots of seed is supervised. The seed which was placed in the emergency store last year has been released since January 30 this year, and the proviso is that corresponding amounts of fresh seed shall be laid down for continued emergency storage for use in 1941.

Permission for import of agricultural root crop seed will in general only be given for seed of original strains from which good results have been obtained in public trials during recent years in Norway and in the country from which the seed has been imported. Imported lots of seed will, in addition to ordinary seed analysis, carry the seller's guarantee certificate for genuineness. For further estimation of genuineness the seed will be after-controlled in public field control of the country in question the following summer.

It is, however, uncertain whether Norway will still be able to import seed of root crops in the coming years, so that it is recommended that every effort should be made to render the country self-supporting in this respect.

Seedsmen have made contracts for more home-grown seed than usual.

Large quantities of seed roots of current varieties and strains of root crops have been stored. This material should be used by growers for seed production, at any rate for their own use. Seed which is produced this year can be stored and used both in 1942 and 1943.

In addition, organized stock seed production has been initiated to produce controlled breeding material for multiplication of trade seed within the country to the extent that conditions render necessary.—R.P.J.

Denmark (489)

Export of white clover seed

Sweden imports some white clover seed from Denmark every year.

In the latest number of *Ugeskrift for Landmaend* it is reported that in Denmark the 1939 seed crop of white clover is far below the average, or approximately 450 tons. The price of white clover seed is high. Economy in mixtures for short duration leys is therefore recommended. In sowing permanent leys care must be taken to see that germination conditions are the best possible. In 1938 and 1939, Denmark's crops of home-grown seed were sufficient for her own requirements and for the export of 258 tons and 150 tons respectively. The present state of affairs emphasizes the fact that Denmark cannot be self-supporting every year where white clover seed is concerned, even if the seed production area is sufficiently large, if the whole surplus is exported, as has happened hitherto. For this reason a reserve should always be retained to carry over to the following year. (*Lantmannen Svenskt Land.* 24. 60. 1940.)—R.P.J.

Switzerland (494)

Agricultural Experiment Station, Zürich-Oerlikon

The report of the Director, Dr. F. T. Wahlen, on the activities of the Station from 1934 to 1938, has appeared in *Landw. Jb. Schweiz.* 54. 271-357. 1940.

In the department of Agricultural Chemistry (report presented by F. Werner) an increasingly large number of grass and hay samples are studied annually for their chemical composition and nutritive value as affected by manurial and cultural treatment, botanical composition, harvesting and curing methods, etc. These studies have led, among other things, to certain conclusions concerning deterioration in hay due to excessive fermentation (see Wahlen and Geering, *Herb. Abstr.* 8. Abs. 1229. 1938, and Geering, *Herb. Abstr.* 9. Abs. 1183. 1939). A tabular presentation of hay ash analyses, 1934-36, shows that a considerable proportion of the land from which hay samples emanated was more or less deficient in phosphoric acid, but only a very small proportion was deficient in potassium, of which the content rose, indeed, as far as the positively injurious point of 5.2 per cent. In another table there is presented the average percentage of crude fibre, digestible pure protein and starch equivalents contained in the hay and aftermath harvested in the years 1934, 1935, 1936 and 1937, the figures for 1933 being given for comparison, at different altitudes, namely, up to 450 metres, 450 to 900 metres, 900 to 1300 metres, and over 1300 metres. A further table shows the average percentage of phosphoric acid, potassium, and calcium contained in the hay from these altitudes in the years 1931-38. Up to 1300 metres the composition of hay samples proves that the meadows are well supplied with phosphoric acid and have an abundance of potassium and calcium ; hay samples from over 1300 metres are, although rich in calcium, poorer in phosphoric acid and potassium.

In the Seed Testing division (report by A. Grisch), clover and grass seed form a very large part of the material received for examination, the proportion having increased somewhat during the years under review. (i) Legumes. Tables show the average figures for purity and germination capacity in ten different species, and the *Cuscuta* content for five species. An increase in the production of indigenous red clover seed is reported, especially in 1937-38. In variety trials of white clover, Ladino, a large-leaved, tall commercial variety, took the first place for productivity, followed very closely by English Wild White : Wild White, however, was more persistent, presenting in the third year a fine, close sward, while the Ladino plots, although still containing a fair amount of clover, had a poorer, more stunted appearance. Most of the lucerne samples received were of Italian and French origin : the adulteration of some so-called Provence lucerne with Argentine or other seed unsuitable for Swiss conditions has been detected and is deplored.

Onobrychis samples came in the main from Moravia. A two-year trial of a Transcaucasian variety, namely, *Onobrychis viciifolia* Scop. ssp. *persica*, grown in comparison with a Moravian variety, *O. viciifolia* ssp. *sativa* [Lam.] Thellung, and the subspecies *arenaria* [Kit.] Thellung, demonstrated the great superiority of the first-named variety, which in the second year flowered three times, the Moravian variety flowering twice only. A note is given of the percentage of hard seeds found in *Lotus corniculatus* and *L. uliginosus* respectively, 1934-38. (ii) Grasses. The percentage purity and germination capacity in ten species is tabulated. Tall oat grass and cocksfoot samples were received from twelve different countries. Of 1067 tall oat grass samples, 143 exhibited a purity of less than 80 per cent, the content of brome grass ranging from 0 to 22.6 per cent, and the highest content of chaff amounting to 28.3 per cent. Analyses are presented of the adulterants found in the tall oat grass and cocksfoot samples respectively. Six samples of *Lolium multiflorum* var. *westerwoldicum* had an average purity of 97.8 per cent and germination capacity of 93 per cent. Of 655 samples of timothy studied for provenance, 235 were found to be of European, and 402 of American origin. The American seed, preponderant in the years 1935-38, was superior in average purity and germination capacity. In 109 samples of *Alopecurus pratensis*, an average of 4.6 per cent of the seed contained larvae of *Oligotrophus Alopecuri*. The percentage of seeds attacked by larvae ranged from 1.2 to 26.9. Most of the meadow fescue samples were of European origin : average percentage of purity and germination capacity in the European and American samples respectively is tabulated. Of *Agrostis* samples, 549 were of American, eighty-one of European, and five of New Zealand origin. Purity and germination capacity in the American and European *Agrostis* samples are compared. Red fescue samples comprised ninety-six of New Zealand and 128 of European seed, the New Zealand seed being superior in average purity but inferior in average germination capacity. Three samples proved to be mixtures of tuft-forming New Zealand red fescue and creeping European red fescue. The worthless nature of some commercial grass seed mixtures is exposed in the report, and the advisability of dealing only with reliable, control firms is stressed. (iii) Miscellaneous forage crops. Average purity and germination capacity are tabulated for several crop plants which include the forage plants *Achillea millefolium*, *Ornithopus sativus*, *Zea Mays*, *Sinapis alba*, *Vicia sativa*, peas and beans.

In connexion with general experimental work, the following notes are of interest. A four-year trial of a large number of soybean varieties proved that the cultivation of this crop is as yet unprofitable under conditions in Switzerland. The yield of grain did not in any variety exceed 20 quintals per hectare, and was often much less. Although the yield of protein and fat per unit area is, on account of the remarkable composition of the soybean, very high, the cheapness of imported soybeans renders their cultivation unremunerative compared with other crops. To grassland research the Station has contributed by two items of organization in particular, that of the Third International Grassland Congress, which took place at Zürich in 1934, and, towards the end of the same year, the foundation of the Society for the Promotion of Forage Crop Production (Arbeitsgemeinschaft zur Förderung des Futterbaues), the offices of which are housed in the Station's premises. The main object of the Society is to co-ordinate the work and experience of the different Institutes and persons, including farmers, engaged in the many different fields of grassland and forage crop cultivation, but it is also able to conduct a certain amount of research of its own. Herein an endeavour is made to arrange a broad division of labour between the Station and the Society, the Station undertaking studies concerned more especially with the artificial production of forage and herbage plants, such as, for instance, the mutual effects of the components of a mixture one upon the other, the number of components of mixtures for different purposes, cover crop and cultural experiments, etc., and the Society undertaking problems concerned more closely with the improvement of natural meadows, grazing technique, and so forth, for which its intimate connexion with practical farming renders it especially suitable. Special attention has been paid to weed control [see *Herb. Abstr.* 10. Abs. 1072 and 1073. 1940] and to the effects of tree growth upon grassland (see Wahlen and Gisiger, *Herb. Abstr.* 7. 252. 1937). The effects of sowing, manurial and cultural treatment under extreme conditions have been studied in connexion with land improvement work near Lake Sihl. Work on field forage

crops has included trials of fodder kales, Sudan grass, and various autumn and winter forage mixtures: an account of these trials is to be published.

The Station's work on plant breeding has been almost entirely concerned with cereals, including *Zea Mays*, but a certain amount of attention has also been devoted to forage plants, *Trifolium pratense* in particular.

Records of injuries to grasses, red clover and lucerne, pulse and soybeans (report by E. Neuweiler) are presented on pp. 353 and 355. Damage was occasioned for the most part by fungi, but there is one case of bacterial disease due to *Aplanobacter Ratheyi* E. Sm. Successful experiments have been conducted in the control of weeds by chemical means. In this connexion an account is given of an apparatus for the eradication of *Rumex obtusifolius*: it is operated by one person, the head of the plant is twisted off by pedal action, and from a vessel a solution of sodium chloride is poured on the wound.—G.M.R.

India (54)

The control of soil erosion

"We are gratified to note that energetic steps are being taken by the Imperial Council of Agricultural Research to fight the problem of soil erosion in this country which here, as in other parts of the world, has led to disastrous consequences of a permanent character to the cropping power of the land. Controlled grazing, contour trenching and bunding are among the methods that have been adopted in India to attack soil erosion and some results of practical value are reported from various parts of the country, where the methods have been under trial for some considerable time.

"Recommendations have also been made for the formation of anti-erosion Provincial Boards and an All-India Anti-Erosion Committee to tackle the problem systematically and to bestow continuous attention to the subject. Among examples of successful attempts are mentioned certain experiments in the United Provinces, where the regulation of grazing resulted in a great improvement in the quality and quantity of fodder grasses and indigenous trees and shrubs, encouraging their natural rejuvenation and effectively preventing soil erosion and the formation of ravines. It was also found that the cutting of grasses twice or thrice a year yielded much more than a single cutting alone and resulted in increasing the yield of fodder grasses from three to fifteen maunds per acre, and that grass samples from enclosed areas were greatly superior in quality to the grass from the ordinary hillsides.

"A notable example of large-scale contour trenching is that carried out in the Singbhum District of Bihar where a distance of 25 miles has been covered with encouraging results. Contour trenching combined with controlled grazing has resulted in striking increases in the yield of grass. These methods are also useful in mitigating the danger of floods, and the Governments of Bengal and Orissa are said to be looking to these methods as practical expedients. In Bombay much has been done by that Government for popularising the methods of constructing field bunds for preventing erosion and in Punjab the Government has accepted a proposal for the grant of remissions of assessment as an inducement for the adoption of the practice by cultivators.—A.K.Y. in *Current Science* Vol. 9. No. 5. 1940.

Agriculture and Animal Husbandry in India

The issue of this publication (issued under the authority of the Imperial Council of Agricultural Research) for the year 1937-8 has been received. The chapters include economic work on crops (fodder crops and grasses, pp. 75-7), research on dry farming, and crop production (plant physiology, pp. 128-34.) The projects have been noted in *Herb. Rev.* 7. 210-8. 1939.—M.H.

Kenya (676.2/9)

Visit of C. Maher to U.S.A.

With the assistance of a grant from the Agricultural Missions Foundation of New York, Colin Maher, Agricultural Officer and Experimentalist in charge, Soil Conservation Service, Department of Agriculture, Kenya, was enabled to make a visit to the United States of America to study the soil conservation research and practices in that country. His report has been published by the Department of Agriculture, Kenya (Nairobi, 1940, price 1s.). Mr. Maher arrived at New York on July 18, 1938 and left again on November 18 of the same year.

In an introductory section, Maher gives a brief outline of the history of the American Soil Conservation Service, notes the new outlook that soil conservation is very largely an agronomic and economic problem rather than a purely engineering one, and that vegetative control measures have largely replaced the use of the more expensive masonry and concrete structures except in special circumstances. A few criticisms are made ; research has been initiated with insufficient preparatory thought ; there is a tendency for over-centralization in Washington ; there is a need for closer co-ordination of work by heads of sections to avoid useless repetition of trials ; there is too much specialization on the part of officers.

After dealing at length with visits to projects, experimental stations and other centres, Maher draws parallels between the agricultural and social features leading towards soil erosion in Kenya Colony and the United States, the differences being only in the matter of scale. He considers the importance of land tenure and economics, and the methods of soil conservation suitable for European and native areas in Kenya. As in the United States, limitation of the rate of stocking of grassland to accord with the carrying capacity of the land is the most urgent and generally the most difficult part of any plan in Kenya for the regeneration of deteriorated grazing land, but failure to do this makes any attempts at pasture improvement useless. Fortunately in Kenya natural regeneration is rapid and limitation of stock alone is frequently sufficient. Mechanical measures to hold silt and run-off water are sometimes necessary in severely overgrazed and eroded areas, and some reseeding may be necessary.

Subdivision of pastures, haymaking, the use of browse plants, succulents and pod-bearing trees, the introduction and trial of legumes such as *Pueraria thunbergiana* and *Lespedeza*, and the procuring of additional water supplies are further methods which are thought worthy of consideration as a result of observations in U.S.A.

As the soil conservation problems in U.S.A. differ in degree but not in nature from those in Kenya Colony, Maher states that experiences in successes and failures in U.S.A. should be considered in planning a soil conservation policy and technique in Kenya.—R.O.W.

Tanganyika (678.2/9)

Visit of G. Milne to U.S.A.

Extracts from the report presented by G. Milne, Soil Chemist, East African Agricultural Research Station, Amani, on a study journey made in 1938 (with the assistance of the Carnegie Corporation of New York) to parts of the West Indies and the United States have been appearing in the *East African Agricultural Journal*.

The first article discusses the relations between soil and vegetation (Vol. 5. No. 4. pp. 294-8. 1940). " A natural plant cover is in many ways an expression of the effective influences of site, soil and climate . . . The inspection of vegetation has sometimes been regarded as a superior substitute for the study of soils . . . The underlying supposition is that all soil properties that are really significant in the given circumstances will receive expression through the plants . . This supposition . . has repeatedly led to mistakes in land utilization, particularly in the exploitation of tropical forests and of natural grassland." If this method is used uncritically, " it is liable to

fail, firstly because botanical science is not yet equipped to apply it, and secondly because of an imperfect appreciation of the nature of the relationship between plants and soil. To be fair to the botanists it should be said that soil scientists have still a great way to go to meet them in the neglected field, which is that of the classification of plants by their nutritional requirements and tolerences . . . . The success of a natural vegetation upon a given soil is not in itself evidence that the soil can successfully support man through the different kind of vegetation that he will establish."

Milne discusses certain observations made during his tour on the basis of the above remarks and notes that there is now " an increasing respect for live plants as accessories to soil management," quoting as non-American examples the development of ley-farming in England (R. G. Stapledon, *Herb. Rev.* 6. 129-45. 1938), and the use of resting periods under elephant grass to relieve the pressure of cotton and grain crops on soils in Uganda. "In the United States, I saw much soil-management practice based on a constructive use of vegetation . . measures consciously aimed at restoring living vegetation to the exercise of a neglected function in soil maintenance."

Unfortunately, the second article based upon this report, on the subject of soil survey, which appeared in the same journal for May, 1940, is not available at the time of writing, due possibly to delay or loss in the post.

The third in the series (*Ibid.* 6. No. 1. pp. 26-31. 1940) is devoted to a discussion of some results obtained by the research workers of the Soil Conservation Service and other branches of the U.S. Department of Agriculture.—R.O.W.

Canada (71)

Experimental substations

The results of experiments at substations in Alberta, North West Territories, Yukon Territory and Quebec for the years 1931 to 1938 are given in a special publication issued by the Experimental Farms Service of the Canadian Department of Agriculture, Ottawa. The stations concerned are Fort Vermilion, Alta., Fort Smith, N.W.T., Fort Resolution, N.W.T., Fort Providence, N.W.T., Fort Good Hope, N.W.T., Carmacks, Y.T., Carcross Y.T., and Betsiamites, Que. By far the greater part of the publication deals with the experiments at Fort Vermilion, where the mean temperatures range from 60.6.F° for July to 12.2° below zero F. for January, and the frost free period averages 72.7 days.

The forage crops used at Fort Vermilion include field roots, field corn for ensilage, sunflowers, annual hay crops (oats, peas, millets), soybeans, alfalfa, red clover, sweet clover, and hardy grasses such as brome, timothy, crested wheat and western rye.

In 1936, all buildings and other equipment of the station were removed to a new site on high level ground of the parkland type, with a grey, transition wooded soil. A special section of the report is devoted to the forage crop trials on this new area, a new feature in this instance being a study of grasses and legumes for seed production.—R.O.W.

U.S.A. (73)

Dr. A. J. Pieters

The following obituary notice by L. W. Kephart is reprinted from *Science*, Vol. 91, No. 2374, pages 610-611. 1940.

Dr. Adrian John Pieters, botanist, agronomist and administrator in the Department of Agriculture for nearly half a century, and world authority on forage and soil-conserving crops, died in Washington, April 25, in his seventy-fourth year. Known, in recent years, as the Father of Lespedeza because of his apostolic leadership in making that soil-building legume a major

crop in the South, Dr. Pieters had a part in a large number of the more significant contributions of plant science to agriculture during the past forty years. In his position as chief of the Office of Seed and Plant Introduction and Distribution he was one of the small group of able men who, in 1901, founded the Bureau of Plant Industry. Subsequently, as head of the section of Clover Investigations and of the Division of Forage Crops and Diseases, and as member of innumerable committees handling matters of Bureau policy, he had a large share in shaping the destinies of that Bureau and, correlatively, of applied plant science throughout the nation. The personalities, the ideas and the ideals of those who thus "set other minds in straight channels" are worth a moment's thought.

Dr. Pieters came to the science of agronomy when that earthy infant was in swaddling clothes. Its garments were sometimes of poor quality and often did not fit. Following horticulture, it was in the process of developing from an art to something approaching a science. Its devotees, of necessity, were mostly men of the soil who, on a foundation of hard realism, had to build a structure that would command the respect of eruditionists. There were not lacking those who scoffed.

Into this situation, in 1895, came a young graduate of the University of Michigan, trained in biology, but with an omnivorous mind. Among other interests which he had or later cultivated were history, literature, farming, languages, jurisprudence, business, bibliography, theology and medicine, in each of which diverse fields he was to become uncommonly well-informed. Nor did he regard these accomplishments lightly. Learning, to him, was not merely a pastime, still less a soporific. It was a live, keen-edged tool made for use. Thus it became his conscious habit to bring to bear on each daily problem different facets of his mind. It might be a proposed law governing the importation of seeds, ergo he considered it with a wide knowledge of its political, economic, legal, historical and biological implications. Even if the problem were of a kind not usually associated with broad culture, as for example—experimental technique, he could see it often from points of view not available to others. Naturally, he had his deficiencies and these he ruefully acknowledged, often lamenting his lack of interest in mathematics, sports, the fine arts and night clubs. Yet certainly he came close to being an intellectual giant simply from the profundity of his general knowledge.

Knowledge alone would not, however, suffice to make him a counsellor of high worth. Perhaps from his Dutch ancestry, perhaps because it was an innate personal trait, he possessed a judicial attitude of truly extraordinary quality. He would have been an incomparable jurist. Few men could see more objectively. Fewer still could exercise the faculty with such complete indifference to the consequences to themselves. No single instance comes to mind when he compromised a solution because of its effect upon his personal welfare. If his decision affected others adversely, he made numberless concessions, but never to himself. Mental integrity, as personal integrity, was to him the cornerstone of character, and his scorn of devious thinking, as of devious intent, was quiet but complete.

Thus there was brought to agronomy at a time when it needed dignity, poise and learning a man who personified those attributes. He helped to give the neophyte science distinction, and lived, fortunately, far into its consummation.

Dr. Pieters' cultural contribution to agronomy was incidental, and probably unconscious. His real contribution was to the economic betterment of American farmers. Following a successful organization of what later became the Department and Congressional seed and plant distribution services, he resigned, in 1906, to organize a seed-producing business in California. Four years later he sold the business at a profit and, after a year at Heidelberg, returned to the University of Michigan for his doctorate. At the request of the late C. V. Piper he re-entered the Department in 1915 to study the causes of wide-spread failure of the clover crop. Within a few years he had determined that the chief cause of failure was unadapted seed, and he was instrumental in causing restrictions to be placed on the importation of unsuitable kinds. Later he turned his attention to the problem of finding legumes suited to growing on the impoverished acid soils of the South. This led to one of the dramatic finds for which the Bureau of Plant Industry is known.

In a small packet of seeds laid aside some time before, he found a new kind of Lespedeza from Korea which, when planted at Arlington Farm, developed such superior qualities that it became, in seventeen years, the basis of a Lespedeza industry rivalling that of clover and alfalfa combined.

He retired, at the compulsory age limit, in 1936, but was accorded the unusual distinction of two presidential extensions of appointment in order that the Bureau of Plant Industry and the Soil Conservation Service might utilize his knowledge.

Dr. Pieters was a fluent but precise writer, and his publications, which number more than eighty titles, are a true cross-section of forage crops, green manuring, and seed production. His unpublished counsels, his delightful wit, his unfailing tolerance, his devotion to truth, his unflagging energy, and his fine, inborn courtesy are in the Department's archive of memories.

Montana Agricultural Experiment Station

The section of the forty-fifth annual report dealing with the Department of Agronomy notes progress on the following projects: crop rotations for irrigated land; comparative yield and quality of new and standard varieties and strains of alfalfa; calcium and sodium chlorate in control of perennial weeds; production of seed of *Agropyron cristatum* under irrigation; alfalfa improvement by breeding and selection; life history of hay and pasture grasses and modifications induced by change in environment (including light and vernalization); selection and hybridization for improvement of hay and pasture grasses.

The Department of Animal Husbandry is studying methods of utilization of grazing lands by range sheep, and the digestibility and chemical composition of range grasses at different stages of maturity.—R.O.W.

Vermont Agricultural Experiment Station

Pasture research at the Station is carried on in collaboration with the U. S. Regional Pasture Research Laboratory at State College, Pa. (fifty-second annual report). A progress report is given on run-off plots on pastures, on the application of boron, manganese, and magnesium with or without phosphate, potash, lime, etc., and on the value of zigzag clover (*Trifolium medium*), *Lotus corniculatus*, certain fescues and wheatgrasses as pasture plants.—R.O.W.

Scientia plantarum

Chronica Botanica was issued as a Reference and Address Book from 1935-1937 and as a Newsmagazine in 1938 and 1939. The latter type of issue is now being continued in the United States as a bi-monthly, under the title "SCIENTIA PLANTARUM, International Plant Science Newsmagazine and Rundschau für die gesamte Pflanzenforschung." The first volume will contain 600 pages, and this will be extended to 900 after the conclusion of the war, when it will also be published more frequently. Volume 1, No. 1 of the new issue will be ready shortly, and will be sent to all subscribers to the former bi-monthly Chronica.

At the request of numerous correspondents the Reference and Address Book is to be continued in a greatly modified form. One part (the Address Book of Taxonomists, Geographers and Ecologists) is ready for publication. The new series of Plant Science Books is being continued in the United States, three volumes being now in the press. The first American catalogue will be issued in the autumn of 1940.

New Zealand (931)

New Zealand Official Yearbook

The forty-eighth issue of this publication for the year 1940 contains, as usual, a wealth of agricultural statistics (Govt. Printer, Wellington, price 7s. 6d.), for example, a classification of the occupied land according to its condition and use (16,783,612 acres in sown grasses and clovers

not cut for hay, seed or ensilage, 39.12 per cent of total), condition and geographical distribution of unimproved land (13,822,137 acres of tussock and other native grasses), area under principal field crops (turnips, and turnips and rape mixed, 385,846 acres ; green fodder, 189,601 acres ; grasses and clovers for seed, 109,695 acres ; grasses and clovers for hay, ensilage, etc., 518,919 acres ; lucerne, 37,023 acres), areas of supplementary fodder crops, areas and yields of grass seed production industry, and the acreage of grassland top-dressed.—R.O.W.

Australia (94)

Council for Scientific and Industrial Research

The Division of Plant Industry has been actively engaged for some years in the introduction of exotic pasture plants (see report for 1938-9). There is need for suitable plants for semi-arid country, legumes for monsoonal country and soil binding plants to combat erosion. Work is also in progress on selecting improved strains of pasture plants and in synthesizing types. The Australian Wool Board has allotted £2,000 to initiate studies in pasture management which Dr. J. Griffiths Davies is to direct.

In the dry season of 1938-9 the outstanding grasses were species of *Bouteloua*, *Sporobolus* and *Panicum*, while species of *Agropyron*, *Bromus* and *Brachypodium* quickly recovered after drought. The report includes results of tests made at Lawes, Queensland, Fitzroyvale, and certain districts in New South Wales. Sward studies were carried out at Duntroon during the year on sixteen introduced grasses, seeded alone and with another grass, and with and without *Trifolium subterraneum*. The best yielding grass was *Bromus arduennensis* (C.P. I. 2382). Data are recorded also on persistency, palatability and germination. Chemical analyses were made on a number of grasses at the flowering stage and the uronic acid content, used as a measure of drought resistance, was determined.

Breeding with pasture plants is carried out at Canberra, Lawes (Queensland), and Moss Vale N.S.W.

Pasture investigations in W. Australia include experimental work on the following : (a) " Stalling " (decrease in yield and invasion by weeds) of *Trifolium subterraneum* ; (b) extension of range of leguminous species now available, and (c) detailed study of *Ehrharta calycina* and of *Lupinus varius*.

At Canberra improvement of pastures without ploughing and the use of sown pastures on land that is under the plough or capable of being ploughed are aspects studied. Increasing the range of superior herbage species capable of being introduced by surface cultivation alone, or the encouragement of the better endemic species by control of grazing and the use of suitable fertilizers form the basis of one attack on the problem. On fallowed land, work on the following three projects has been commenced : (1) comparison of a representative range of grasses and legumes as simple grass-legume swards ; (2) a strain trial of the commercially more important herbage species, and (3) establishment of 22 acres of a mixture of *Phalaris tuberosa*, *Dactylis glomerata*, *T. subterraneum* and *Medicago*. The pasture will be subjected to specified grazing treatments in the second and subsequent years.

A report on a survey of pasture problems in Southern Queensland is in course of preparation.

Entomological investigations in regard to field crop and pasture pests concern locusts, *Oncopera* spp., *Halotydeus*, and *Bruchus pisorum*. Entomological control studies are in progress with *Hypericum perforatum*, *Xanthium pungens*, *Lantana camara*, *Senecio jacobaea* and *Cyperus rotundus*. Chemical, cultural and other forms of control are also reported for certain weed species.

Agrostological investigations reported under the Animal Health and Nutrition Section include study of sown pastures and cereals on copper deficient soils, and experiments at Clare (see *Herb. Abstr.* 9. Abs. 1284. 1939) and at Wambanumba.

[See also Bulletin No. 29 from this Bureau.]

Waite Agricultural Research Institute

A section of the Reports for 1933-6 and 1937-8 dealing with the water requirements of pasture plants has been reviewed in *Herb. Rev.* 5. 158-60. 1937. The reports also contain information concerning the following projects :

Permanent rotation experiments. A series of permanent rotation plots was established in 1925 to determine the yield of wheat grown under various systems of rotation cropping in the Adelaide environment. The normal cultural practice in the wheat belt is to precede the wheat crop with a well-worked fallow and to include either oats, barley or temporary pasture in the rotation. In the higher rainfall areas peas or fodder crops fed off with sheep are used in rotation with wheat. The rotation which has consistently shown the highest yield of wheat is of the four-course type, with only two cereal crops in four years, namely, wheat, oats, pasture and bare fallow. The ten-year average yields are : wheat, 44.38 bushels, oats, 59.87 bushels, and Wimmera rye-grass (*Lolium* spp.) hay, 32.93 cwt. per acre. Yield of wheat grown continuously on the same land for ten years has averaged 17.03 bushels.

Investigations have been made on the effect of forage crops and temporary pasture on yield of wheat in four-course rotations. Results, from two years observations only, show that yield of temporary pasture is greater after grazing the previous forage crop than after cutting for hay. Further, the highest yield of pasture has been obtained from the rotation fallow-wheat-peas-pasture, in which grazed peas preceded the pasture.

Permanent fertilizer tests. A series of permanent tests with artificial fertilizers was established in 1925 to determine the immediate and cumulative effect on wheat and barley of varying quantities of soluble phosphate and different forms of phosphatic fertilizers with supplementary dressings of nitrogen, lime and potash. The most significant yield increases were obtained from superphosphate. The indirect effects of the heavier applications in promoting growth of *Medicago* and *Trifolium* spp. on the stubbles and in increasing the stock-carrying capacity of the farm are important. At the end of the ten-year period the tests were redesigned with a view to obtaining information on the effect of nitrogen, phosphorus and lime applied singly and in combination at three different levels to the following rotations : (a) wheat, oats, temporary pasture, fallow ; (b) wheat, barley, temporary pasture, fallow.

Fertilizer and time and rate of sowing tests with *Phalaris canariensis* have shown that highest yield is obtained with 24 lb. seed and 2 cwt. superphosphate per acre. Maximum seed yield (14.7 cwt. per acre) was produced by early seeding.

Pasture investigations. The problems under investigation are discussed under the sections (a) top-dressing natural pastures, (b) pasture technique, (c) tests with cultivated pasture plants, (d) strain investigation of cultivated pasture plants (*Phalaris* spp., *Lolium perenne*, *Bromus* spp., and *Trifolium fragiferum*), (e) pasture establishment (on areas at the Waite Institute, at Mount Barker, on irrigated areas and on different soil types), (f) grazing value of pastures, (g) comparison of natural and seeded pastures, (h) management of seeded pasture, (i) application of fertilizers to pastures on different soils, to a seeded pasture mixture under hay and grazing treatment, (j) effect of P and N alone and in combination on yield and botanical composition of two different pasture mixtures, (k) associated growth in pastures, (l) classification and zonation of South Australian pastures, (m) study of a typical Mitchell grass (*Astrebla* spp.) pasture in Queensland.

Plant physiology. Growth studies reported include observations on ontogenetic drifts under different initial nutrient supplies, and the object of work in progress is to relate effects of N and P supply on relative growth rate and its factors to effects on chemical composition of the plant, especially as regards proteins and complex phosphorus compounds. This section of the report also includes information on nitrogen metabolism, and the relation of transpiration ratio to nutrient supply.

Systematic botany. Investigational work includes study of plants as potential sand binders, or drought resistant fodders, preliminary to initiating a scheme in connexion with soil erosion problems. Excursions have already been made into dry districts to obtain the necessary supply of seed.

Chemistry of pasture plants. This work is complementary to agronomic studies of cultural methods, fertilizers and the introduction of new species and strains of fodder plants. The influence of these factors on the composition of pure species and of pastures has been studied in pot culture experiments and in field plots.

Entomological work relating to pastures. These studies include observations made in regard to *Sminthurus viridis*, *Halotydeus destructor*, the *Aphodius* pasture grub, field crickets (*Gryllus* sp.), the boll-worm, *Heliothis armigera* (responsible for the non-setting of lucerne seed in northern lucerne areas), and the moth, *Oncopera* sp., the larvae of which may cause damage to pastures in parts of the south-east.

Plant breeding and genetics. Work in progress with *Phalaris tuberosa*, *Lolium perenne*, *Bromus unioloides*, *Trifolium subterraneum*, *Medicago tribuloides*, creeping lucerne and *T. fragiferum* is reported. A pedigree strain of *P. tuberosa* is being tested as an improved pasture type ; a sward trial with selected *L. perenne* is in progress for comparison with commercial strains ; eight genetically stable types of *B. unioloides* are recognized and the influence of the biotic factor in their segregation is stressed. During 1937-8 the grazing value of representatives of the eight types has been assessed by the use of replicated grazed swards ; work with *T. subterraneum* was designed to determine the value of types already segregated and named by the various State departments of agriculture ; during 1937-8 a collection of forty-six strains of *Medicago tribuloides* was made. These have been sown to select productive strains of improved burr type ; a breeding programme initiated in 1934 with the objective of producing a commercial creeping type of lucerne adapted to grazing conditions is in progress ; *T. fragiferum* is gaining in importance on the rendzina soils of the south-east of the State, and the breeding programme involves the production of a strain suitable for pasture purposes.

Investigations in regard to soil erosion and pasture regeneration. The work is located at Yudnapinna and Pallamana. A trial of approximately fifty dry-land pasture species, selected on a basis of performance at Pallamana, and of a number of tree and shrub species has been started. Further, an experiment designed to supply information on the establishment, persistency and productivity of various combinations of leguminous and non-leguminous plants on a typical Mallee soil at Pallamana was commenced in 1938.

Mineral deficiencies. Conditions governing the absorption of certain trace elements are being investigated by means of pot experiments and water cultures. A survey is also in progress to determine the normal range in plants of the amounts of such elements as Mn, Cu, and Zn. Improved methods have been worked out for the accurate determination of these elements in plant material.

Work on Cu deficiency in relation to "coast disease" has been done in association with the Animal Nutrition Laboratory. The deficiency occurs on a highly calcareous soil and the natural pastures on such soils are usually composed of inferior annual grasses such as *Lagurus ovatus* and *Bromus madritensis*. Legumes are scarce or absent. See also *Herb. Abstr.* 8. Abs. Nos. 1236 and 1764, 1938.

In experiments made in co-operation with the Animal Nutrition Laboratory, the comparative resistance of different plants and the symptoms produced by Cu deficiency have been studied.

Field pasture trials are in progress and promising results have been obtained with *Medicago lupulina*, perennial and Wimmera ryegrass, *Dactylis*, *Phalaris tuberosa* and *Holcus lanatus*, sown with 28 lb. copper sulphate per acre.

Chemistry of pastures. In 1937 an experiment was begun in collaboration with the Research Department of the Australian Estates Co. Ltd., on the sheep station "Elderslie," near Winton, Queensland, and designed to determine seasonal yield and composition of a Mitchell grass pasture typical of the pastoral belt of Western Queensland. Chemical analyses of samples taken at 28-day intervals throughout the year demonstrated the existence of wide extremes in nutrition value. See also *Herb. Abstr.* 8. Abs. 1090. 1938.

These experiments have been followed by work in the Australian Estates Company's Research Department in which a series of trials on supplementary and drought feeding is being carried out.

Other investigations at the Institute have been noted in *Herb. Rev.* 5. 200-2. 1937 and *Herb. Abstr.* 9. Abs. 516. 1939 and in *Herb. Publ. Ser. Bull.* 29. Data are also available on (1) the effect of grazing management on yield and chemical composition of pasture consisting predominantly of *Phalaris tuberosa* and *Trifolium subterraneum* and (2) digestibility of hays produced under different stocking rates.

Department of Agriculture and Stock, Queensland.

The following are extracts from the report of the Director of Plant Industry (Research) for 1939 :—

Agricultural Section. A study of sorghum yields and seed production has been carried out at the Biloela Research Station and in the Kingsway district. The general results obtained in the experimental programme and in the commercial plantings during the season show the advisability of growing sorghums on an extensive scale both for grain and fodder production in most districts receiving less than 30 in. rain in the south-eastern and central sections of the State.

Pasture renovation and legume adaptation experiments have been initiated at Dayboro and Cooroy.

Experimental plots established in the Blackall district inidcate that soil type influences rate of regeneration of the vegetative cover under the different treatments studied. An area in the Tara district reclaimed from *Opuntia* sp. is being studied with a view to utilizing the area for sheep raising.

There are tests in progress on (1) the merits of sowing a grass broadcast in wide areas compared with 3 ft. strips of grass alternating with 3 ft. cultivated strips of bare soil, using *Chloris gayana* and *Panicum antidotale* on the Roma Demonstration area and Rhodes grass in 5 ft. strips alternating with 4 ft. cultivated areas at the Biloela Research Station ; (2) storage of nutrients in *Astrebla lappacea* ; (3) feeding trials at the Yeerongpilly Animal Health Sta., in which *Threlkeldia proceriflora* (soda bush) was proved poisonous ; and (4) plant introduction trials at Moggill, near Brisbane.

Botanical Section. An instance of *Lepidium ruderale* causing turnip-like taint in meat is reported.

Bureau of Tropical Agriculture. Activities of the Bureau are recorded under sections which include pasture development (tests with mixtures, fodder legumes, palatability trials etc.), lucerne experiments, fodder trials, and agricultural research on the Atherton Tableland.

Entomological Section. Of pasture pests, *Pleidole impressiceps* (in *Chloris* areas), *Psara licarsisalis, Spodoptera exempta, Lepidiota caudata* and *Agrotis ypsilon* (on lucerne) are recorded.

Plant Pathological Section. An observation plot has been established at the Queensland Agricultural High School and College at Lawes to study development and spread of witches broom on lucerne, and control measures are being studied with *Sclerotium rolfsii* and *Helicobasidium purpureum* which cause depletion in lucerne stands.—M.H.

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IMPERIAL BUREAU OF PASTURES AND FORAGE CROPS

This Bureau covers literature on grassland and forage crops, the botanical aspects of soil conservation, and certain plant biological research. It issues two quarterly journals:

HERBAGE ABSTRACTS

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BULLETIN No. 26, PUBLISHED SEPTEMBER, 1939

"Research on grassland, forage crops and the conservation of vegetation in the United States of America"

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BULLETIN No. 27, PUBLISHED JANUARY, 1940

"The control of weeds"

(A symposium on current research and practice in the eradication of undesirable plants in arable land, grassland, etc., by cultural, chemical and biological means.)

Contributions by: T. K. Pavlychenko and R. H. F. Manske (Canada); L. W. Kephart, A. S. Crafts, R. N. Raynor, and J. Monteith, Jr. (U.S.A.); B. Rademacher (Germany); G. A. Currie and A. P. Dodd (Australia); E. Bruce Levy and D. Miller (New Zealand); D. G. Steyn (South Africa).

Pages: 168. Fully illustrated. Price: Seven shillings and sixpence.

BULLETIN No. 28, PUBLISHED JANUARY, 1940

"Technique of grassland experimentation in Scandinavia and Finland"

Pages: 52. Price: Two shillings and sixpence

BULLETIN No. 29, PUBLISHED JANUARY, 1940

"Grassland investigations in Australia"

(This Bulletin gives notes on the work of institutions engaged in grassland research, followed by a series of special articles on the Australian environment, plant introduction, plant breeding and selection, northern and southern Australian pastures, and weeds and insect pests. Special articles are also devoted to the pasture investigations in the State Departments of Agriculture and at the Waite Institute. The final part contains 247 abstracts on grassland in Australia)

Pages: 107, maps, index of genera. Price: Five shillings

BULLETIN No. 30, TO BE PUBLISHED OCTOBER, 1940

"The grasslands of the Argentine, including Patagonia"

By
William Davies, Welsh Plant Breeding Station, Aberystwyth.

A report of a tour of South American grasslands made during March and April, 1938, describing the eight grassland zones, and giving detailed notes on visits to individual Stations in Patagonia and Argentine proper.

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IMPERIAL AGRICULTURAL BUREAUX, JOINT PUBL. No. 3, MARCH, 1940

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(See inside back cover)

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